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A TREATISE UPON RAILWAY SIGNALS AND ACCIDENTS

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TREATISE

UPON

RAILWAY SIGNALS

AND

ACCIDENTS.

BY

ARCHIBALD D. DAWNAY,

ASSOC. INST. C.E.

2

LONDON:

E. & F. N. SPON, 48, CHARING CROSS.

NEW YORK:

446, BROOME STREET.

1874.

Transportation
TF
615
.D27

LONDON: PRINTED BY WILLIAM CLOWES AND SONS, STAMFORD STREET AND CHARING CROSS.

RAILWAY SIGNALS.

PART I.

On the railways in the United Kingdom there are from 600 to 1000 persons killed annually, and more than double that number injured from all causes; but the greater proportion of these casualties are directly attributable to the sufferers' own inadvertence in various ways, as only an average of twenty-five persons are killed and 1000 injured from causes beyond their own control, and attributable to some one or more of the accidents technically termed "train accidents;" but it does not follow that, because some 180 individuals lose their lives in joining, leaving, or falling from trains, and 600 more by trespassing on the line, by suicide, or while pursuing their avocations in connection with the traffic, the railway companies should by their negligence, or that of their employés, cause the death or injury of even one person.

Train accidents are divided into the following heads:—

1. Collisions between trains going in opposite directions.
2. Collisions at stations or sidings.
3. Collisions at junctions.
4. Collisions between trains following each other on the same line.
5. Trains running on to wrong lines, through facing points or by striking against them, and by points being wrongly turned.
6. Trains entering stations at too great a speed.
7. Failures in construction of rolling stock.
8. Obstructions on the rails, or defects of the permanent way.
9. On inclines.

The Board of Trade Report of 1872 details 238 accidents

under these heads, which are subdivided into 14 classes, giving,—71 instances of defective signals, points, or locking apparatus; 42 of insufficient means of securing intervals between trains; and 180 of negligence or mistakes of servants: thus showing that an accident is frequently the result of a combination of causes acting simultaneously or in quick succession.

If in the course of a single year there arise nearly 300 direct causes of accident mostly preventible by the adoption of various recognized means, but which, from a mistaken economy or wilful neglect, railway companies decline to avail themselves of, it is not too much to say that a very grave charge lies at their door, one which sooner or later they must be called upon to meet; for it can be only reasonable to suppose that every passenger who entrusts himself to be conveyed by a company, however short the distance, should demand, and be entitled to, every possible known means being employed to ensure his safety; but by some extraordinary rule of contrary, and notwithstanding all the pressure which has been brought to bear upon the companies, they are not yet sufficiently convinced of the necessity of augmenting the provisions for working the constantly increasing traffic without mishap; hence scarcely a day has passed since the middle of 1873 which has not added one or more catastrophes to the already appalling list, and while this is being penned, the public are horrified with the details of the Manuel Junction, West Drayton, and Euxton collisions, destroying the lives of nineteen persons and maiming many others.

To secure the safe and expeditious transit of trains, the efficient working of signals is of paramount importance; but the subject has not hitherto received that consideration in a collective form which, upon close observation, it will be found to deserve, therefore it is proposed to lay before the public as briefly and intelligibly as possible the result of a careful investigation, which will be better explained if arranged under the four following divisions:—

1st. The development and form of signals in use upon railways from the earliest time.

2nd. The various patents and improvements deserving of note.

3rd. The practical results of the several systems, deduced from the accidents which have occurred; and

4th. To consider what methods of signalling and working of traffic appear most desirable to ensure safety.

First, as to development. The necessity of transmitting intelligence from one place to another by indications at a distance without the employment of a carrier, and with greater rapidity and certainty, was evidently felt by the ancients, and many were the expedients resorted to under various circumstances; they were mostly simple, and possessed of little mechanical contrivance.

The earliest telegraph of which there is any authentic record is referred to in the 10th book of Polybius, who also mentions a mode of telegraphy invented by Æneas, a writer upon the art of war, by which he transmitted entire sentences; and in his 'Punic War' he makes mention of naval signals having been used.

Rollins, in his 17th book of Ancient History, gives an elaborate account of torch signals.

The Speculatores and Vexillarii of Ammianus Marcellinus were officers presiding over and directing the signals or telegraphs, but it is difficult to trace any distinct form of semaphore until about the middle of the 17th century, when the French constructed one of three movable wings or arms, sliding from side to side of a sustaining mast by means of a counterpoise and centre-pin; certain movements of the arms in combination indicated words or letters. About the year 1684 a Dr. Hooke appears to have invented the form shown by Fig. 1. This was revised by a Rev. W. Gamble in 1795, who styled it the radiated telegraph, Fig. 2. Further improvements

FIG. 1.

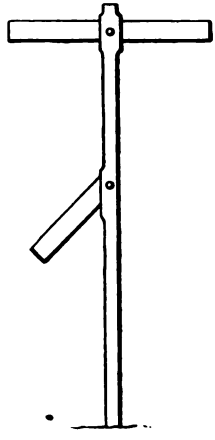
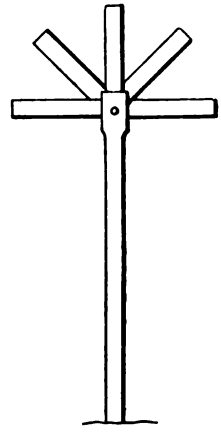
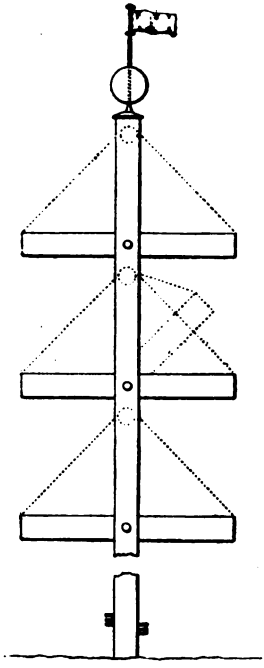


FIG. 2.



were made in 1804, and in 1809 the so-called "New Semaphore" system was invented by one Macdonald, and submitted by him to the Admiralty in 1812; it was subsequently adopted, and used for some time on the east coast of this country. It was constructed with a mast about 56 feet in height, 10 to 12 inches square, having six arms 6 feet long and 18 inches wide, worked on a pivot by ropes; a vane rod and sliding ball, termed the auxiliary ball, surmounted the mast; in fair weather, with the use of glasses, readings were taken at distances of ten miles, Fig. 3.

FIG. 3.



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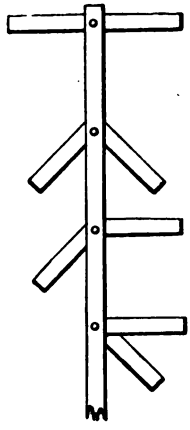
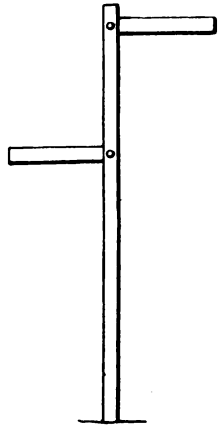


FIG. 5.



In 1816 Rear-Admiral Popham introduced the semaphore form, in Fig. 4, and Lieut.-Colonel Pasley in 1822 used what was termed the "Universal System," Fig. 5, which was similar in detail to the French coast-semaphore invented in 1803 and Dr. Hooke's form of 1684; but from 1822 to the commencement of the railway period no further important modifications appear to have been made.

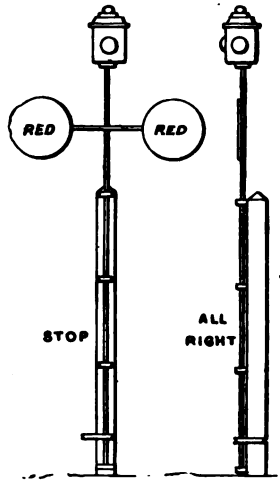
The necessity of these remarks upon what may be properly called "Telegraphy" will become more obvious presently.

When the construction of a railway was sufficiently advanced for preparations being made to establish regular traffic, it of

necessity occurred to the engineers that some method of regulating the passage of trains must be adopted, otherwise constant collisions, either between trains on the same line of rails or while in the act of crossing from one line to another, would be the result; it does not seem that any well-devised plan was thought of before the actual necessity occurred. In most instances the engineers or the traffic managers set up their own form of signals, fixed or portable, without consideration of those used on other lines, even if working in connection with their own, and the natural result is that the systems adopted are exceedingly diversified and unharmonious.

A misapprehension even as to the utility of signals generally appears to have arisen in the minds of some, judging from a letter written by Mr. Prosser, of Birmingham, to Mr. Moss, of the Grand Junction Railway, in January, 1838, in which he remarks that "No system of telegraphic signals (not electric telegraphic) of ordinary kind can be serviceable on a railway, because that implies that the road should be divided into stations, and an accident could not be communicated without loss of time;" but he offers no suggestions as to what kind, if any, would be desirable; nevertheless signals were adopted, of the following variety of forms:—

FIG. 6. FIG. 7.



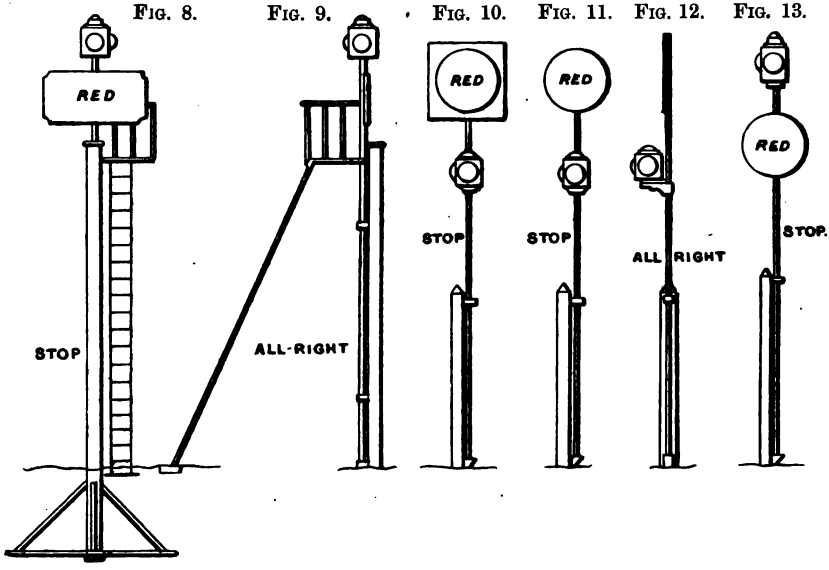
The Manchester and Liverpool Railway had disc station signals and no distant; the Lancashire and Yorkshire spectacle discs, Figs. 6, 7.

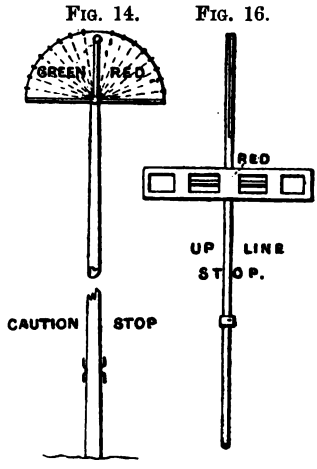
The Midland distant signals consist of rectangular boards painted red, and affixed to turning posts, Figs. 8, 9.

The London and Birmingham, and North-Eastern, discs of different forms and dimensions, Figs. 10, 11, 12, 13.

The Dublin and Kingstown, red flags; the Great Western, red and green flags stretched on a bow supported by a mast and drawn close or open by a cord, as need required, Fig. 14; and afterwards the "cross-bar

and disc," Figs. 15, 16, with a fantail board, principally used for giving caution signals, Figs. 17, 18.





The Brighton and several other southern lines use semaphores as well as spectacle discs, Figs. 19, 20, 21; and the London and South-Western have a half disc, entirely distinct from all others. They are worked by means of ropes and pulleys, by which the disc is revolved upon a centre-pin, or sometimes the mast itself is turned round. The station and distant signals are shown by Figs. 22, 23, and 25, and the branch-line signals have a wide green-painted ring fixed round a lamp placed below the disc, as Fig. 24.

In 1838 a signal was erected at the Vauxhall Bridge, Birmingham, invented by a Dr. Church. It was connected to the

FIG. 17.

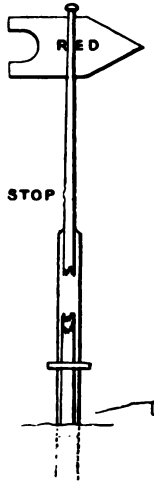


FIG. 18.

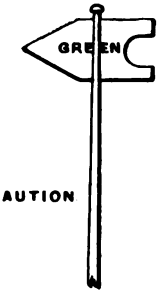


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FIG. 19.

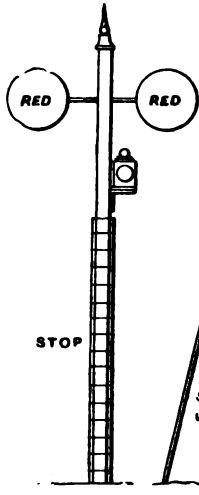


FIG. 20.

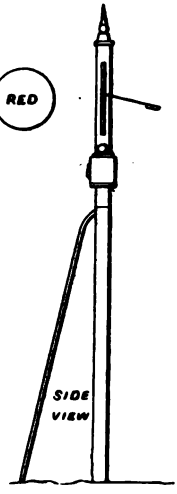
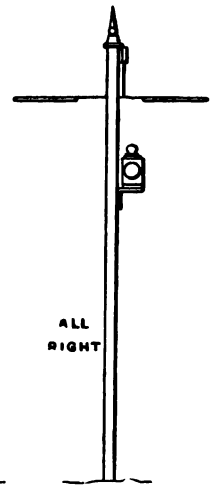
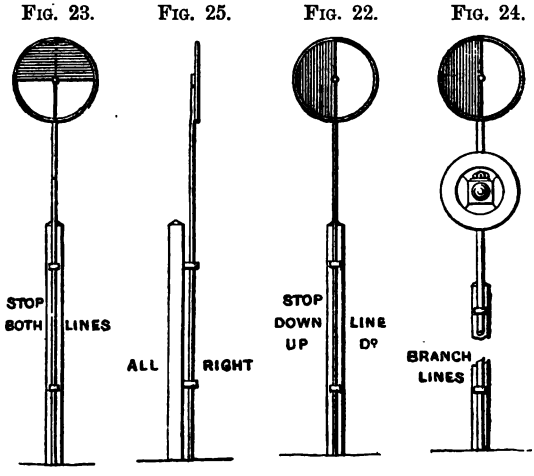


FIG. 21.



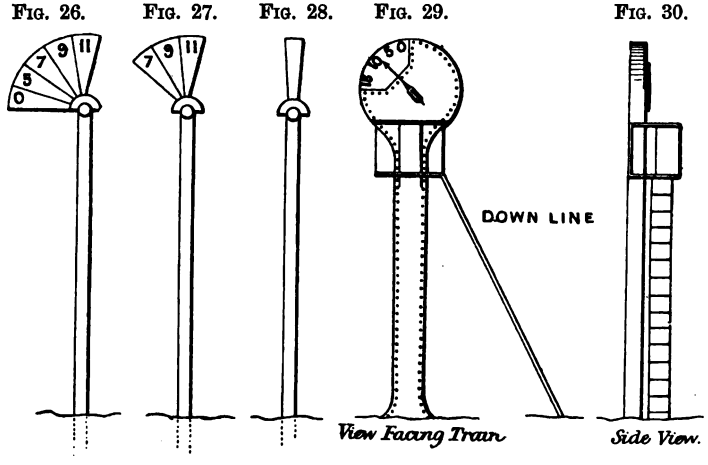
points and stood about 5 feet high, having two discs, 2 feet in diameter, fixed at right angles to each other, and surmounted by a lantern showing four lights, two red, one blue, and one

white; the discs were painted to correspond. The intention was to indicate the state of the points. It acted very well for



some years; but on an alteration being made in the line it was removed, and not re-erected.

A somewhat complicated signal, Figs. 26, 27, 28, was invented



by a Mr. C. Hall, and adopted by the Eastern Counties Railway in 1842. It consisted of five leaves put together in the form of a fan, and coloured yellow, green, red, and white; each leaf

indicated the time a train had passed it. A green post was fixed at the side of the line 100 yards in advance of the signal, beyond which no train was to go if the fan exhibited the red leaf; a green post with white stripes was fixed a mile on the other side of the signal, and if the fan showed the 7 or 9-minute colour when passed, the train on reaching the post might put on full speed. This system was in use several years, but the date when it was wholly abandoned is somewhat uncertain.

In 1863 the Midland Company erected a self-acting time indicator at Kegworth, Figs. 29, 30, showing the time a train had passed up to fifteen minutes. It was set in motion by the passing train depressing a lever attached to the rails and communicating with the clockwork; at the expiration of the fifteen minutes the pointer returned to its normal position; it has since been abandoned, as not proving sufficiently reliable. At Whiston Bank, on the Liverpool and Manchester line, a train-actuated signal was in use in 1867, but it was subject to failure; the same result has also attended the use of similar signals on the Brighton line, and they were both ultimately abandoned.

Whitworth's train-actuated discs were adopted at the tunnels of the Lancashire and Yorkshire Railway, and when turned to danger as the train passed, a bell rang at the other end; the signalman had to release the signal when the train left the tunnel. In 1858, one Baronowski obtained the consent of the North London Company to erect and test his "automaton" signal between Hackney and Kingsland. It was set to danger by the passing train pressing down a lever which actuated the mechanism, raising the semaphore to danger, and when the train reached a distance of 1100 yards beyond it pressed down another lever, causing the danger signal previously set to be released. The working was successful during the passage of many hundreds of trains; but its failure on one occasion was supposed to have caused a serious accident, and subsequently its removal was determined on, it not being thought sufficiently reliable.

On the Greenwich line, plain posts were fixed to each road at half a mile on either side of the junction, on reaching which the engineman opened the engine whistle, and the switchman

notified by hand flags whether the main or branch-line train was to proceed.

The Hull and Holderness Railway Company used a balance cross-bar semaphore, Figs. 30*a*, 31; and besides these varieties there are a number of special signals at present in use, each having an almost distinct form: Figs. 32, 33 is the platform signal at Broad Street Terminus; Figs. 34, 35, at the goods shed, Chalk Farm; Fig. 36 on the South London line. Engine signals on the Brighton line are shown by Figs. 37, 38. Point signals on the South-Eastern, Figs. 39, 40, 41. Branch-line point indicators, Figs. 42, 43, 44. There are a

FIG. 30*a*. FIG. 31.

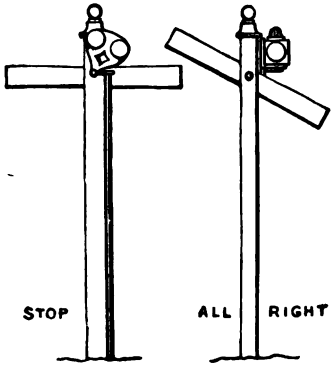
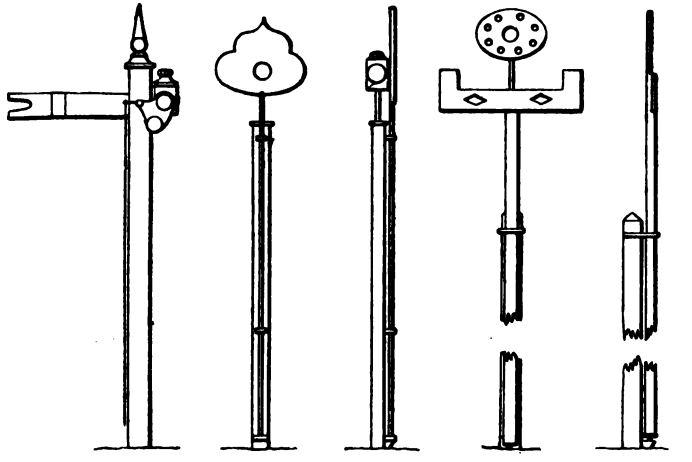
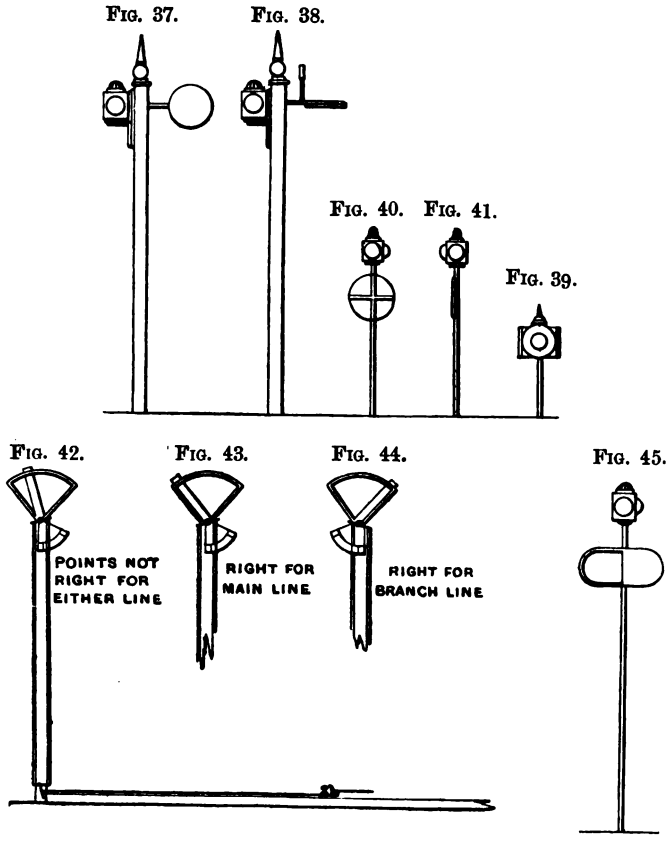


FIG. 36. FIG. 32. FIG. 33. FIG. 34. FIG. 35.



number of other forms of lamps and coloured discs used for similar purposes, which are technically called "footlights." The discs have a coloured glass fixed in the centre, just covering the lamp bull's-eye, and moving over its face with the throw of the points. Fig. 45 is a signal formerly in use on the *Blackwall Railway.*

Some companies have adopted platform signals for starting the trains, which are worked from the cabins, and where these



are in use manual signals are as a rule prohibited, and no driver may start his train until the signal indicates all-right. The most complete working of this kind is on the Metropolitan underground lines.

In situations where masts cannot be conveniently erected, a balance-arm is frequently attached to the brickwork or girder of a bridge, as Figs. 46 to 50.

Those railways which had no fixed signals were generally regulated by hand flags and lamps, or flags and discs temporarily hoisted upon poles; and manual signs given by the police, *who traversed* certain beats between the stations, or

were located at permanent points along the line, and timed the passage of the trains, whether goods or passenger, by the code set

Fig. 46. Fig. 47. Fig. 48.

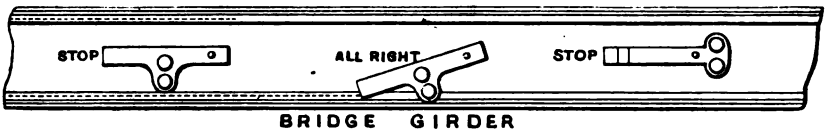
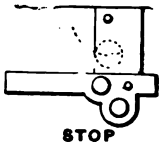


Fig. 49.



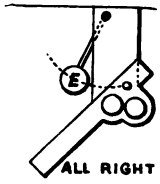
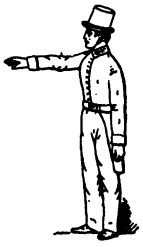


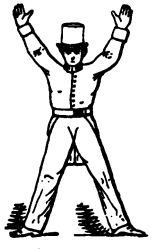
Fig. 50.

forth in the book of regulations. This system involved a considerable outlay, it requiring a large staff of men, who unfortunately were not always of the best and most reliable character; gradually they gave place to fixed signals at the crossings and tunnels, and at a lesser number of intermediate spots between the stations than formerly occupied by them, and even then the station, or home signal, was only adopted; distant or auxiliary signals were not thought needful.

Among all the various systems, uniformity of colour only was observed, *viz.* red for danger, green for caution, and white, all-right; the manual signs were given mostly by the signalman holding out one arm horizontally for all-right, Fig. 51; caution was given by holding up one hand vertically above the head, Fig. 52; and danger by extending both arms in a similar manner, Fig. 53. This code still exists, and is used almost universally in combination with small red, green, and white hand-flags.

Fig. 51. Fig. 52. Fig. 53.





It will not be considered surprising that the dissimilarities in signal arrangements which have been mentioned were at all times strongly condemned by the various

Government officials and others as prejudicial to safety, especially in the working of through traffic. Bearing upon this point, Mr. Robert Stephenson, when before the Railway Committee in 1839, in reply to Mr. Locke's question 4738, "That there would be a difficulty to a locomotive of one company travelling over the line of another company in consequence of the different signals," said, "Yes, as they now exist I know them to be very different;" and to the next question, "Would it, in your opinion, be at all useful that there should be a superintending board which should regulate the different railways, including signals?" he replied, "I think that is the only tribunal that would be really useful whenever a difference arose." On the 19th January, 1841, a general meeting of delegates from the principal railways was held at the Saracen's Head, Birmingham, when it was resolved "That this meeting considers it desirable that there should be an uniform system of signals recognized and applicable to all railways;" and they then recommended to the various companies the adoption of a set of rules and regulations suited to the carrying out of their resolution. Very little good, however, resulted from this until 1847, when Captain Huish, the then manager of the London and North-Western Railway (which had become an incorporation of five different companies), published a code in the form of an octavo book of 98 pages for the use of his line; and he at the time stated, as the result of his practical observance, that "he found on the amalgamation of the five different companies that it was necessary, to the proper working of the several lines in unison, that there should be one acknowledged system;" also, "That it was desirable that a driver or guard who had been obeying the system of one line for years could change to another without having to learn or unlearn anything either in signals or lamps or engine fronts, unlearning semaphores and learning discs and cross-bars, or unlearning either and learning the red and green flag system." He further remarked that the Great Western, South-Western, and Brighton Companies' signals were, though unlike, most serviceable; their only faults being that the masts, as a rule, were not sufficiently high. As an evidence also of public opinion on the subject of uniformity, the 'Morning

Herald,' in November, 1847, remarked, "We have long been impressed with the opinion that an uniform system of signals and code of regulations for the management of railways should be adopted throughout the country, and must be adopted before the now natural means of communication can reach the state of perfection which we hope to see it attain."

Notwithstanding the strenuous endeavours of Captain Huish to effect uniformity on his line, it was reported in 1848 that the system of signals on the main line as far as Preston was alike; then for 20 miles beyond another prevailed; and after that the former was resumed to Forfar, and this for the working of "through trains" by the one company.

The Board of Trade and their inspecting officers have repeatedly enforced the necessity of uniformity; but further than that they had no authority to go, as the Government had abstained from interfering with the regulation of railway traffic, excepting in that it gave the Board discretionary power as regards the construction and general arrangements; they were to issue regulations for the prevention of accidents, which would not affect speed and time, or touch the questions of signals. As a rule, the recommendations of the officers were met with considerable opposition, and indeed in some cases with positive refusal.

It is remarkable that, in spite of all that has been urged from time to time by so many eminent men, during the past thirty years the systems of signals should be as diversified as we now find them. The Great Western Company still use the cross-bar and disc and fantail; the Midland, Lancashire, and Yorkshire, Brighton, and several other lines, discs of various forms, variously worked. The South-Western still use other forms of half discs, although only partially, and if possible to make matters worse, they all more or less use the semaphore in conjunction; at the same time it cannot but be admitted that rapid strides have been made towards a similarity; but there remains much to be done before a properly organized system can be said to exist.

The time allowed for the exhibition of the danger and *caution* signals, after the passage of various classes of trains, is

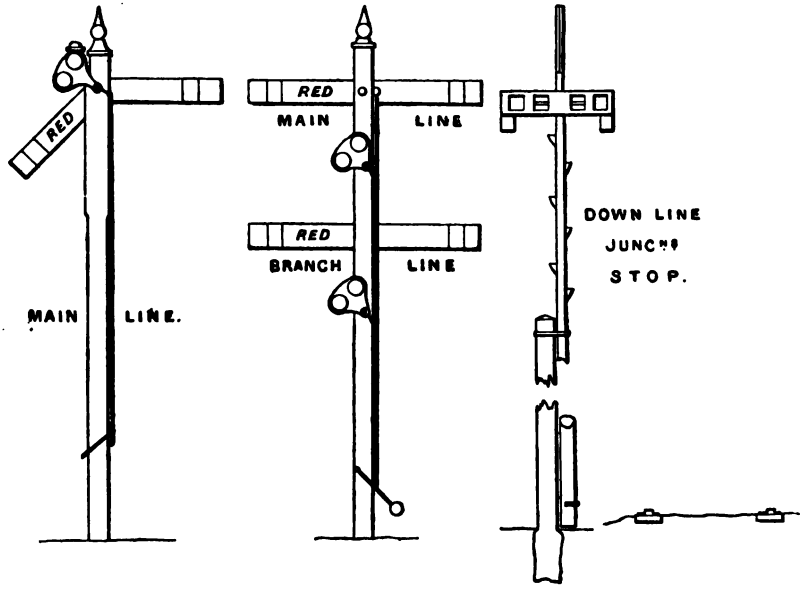
not quite alike on all lines; it varies from 3 to 5 minutes for the danger, and 5 to 8 minutes for the caution; this latter signal is to a great extent becoming disused, especially on lines worked by the "absolute block" system, whereby the lengths or stages into which they are divided are either "blocked" or "clear." There are also several methods of regulating the traffic, which are frequently worked together on the same line; one part is by "absolute block," another by "permissive block," and a third simply by "intervals of space," each in themselves requiring an almost distinct code of instructions, both for signalmen and engine drivers.

With a view to secure the services of thoroughly intelligent men for drivers, seeing that in addition to the responsibility attached to their merely driving an engine and their having a practical mechanical knowledge, they had very much to learn in signals, time, and many relative matters, the officers of the Board of Trade in 1840 suggested the establishment of an Examining Board for granting licenses to engine drivers. The candidates were to be brought forward by the railway companies requiring men, and examined by two gentlemen nominated by the Board of Trade, with whom all decisions were to rest. The certificated drivers were to wear a badge, and the power to cancel or suspend a license, or to dispose of any held by men who had quitted the service or had received their dismissal, was vested in that Board. To some extent the granting of certificates might have been attended with beneficial results, but unfortunately the proposition speedily fell to the ground.

The form or outline of signals regulating both the up and down roads are with one exception similar, when viewed in either direction; it is the red colour and the side of the mast on which the arms are pivoted that indicate to the engine driver the road it governs, Figs. 54, 55. It is understood to be the rule—or, as some companies' books on signals state, "it is invariably" the rule—that the arms on the left side of a mast govern the near or left-hand roads, irrespective of the side of the road on which the mast is placed; but in the case of discs seen from a distance in hazy weather, or when the colour is faded, they may be taken for either road, especially in passing round a

curve. The exception alluded to is on the Great Western, where two downward ears are added to the cross-bar to distinguish the down signal from the up, on whichever side it may be seen, Fig. 56.

Fig. 54. Fig. 55. Fig. 56.



There are very few instances where the several arms on the same side of the mast are distinguishable for the trains they regulate, beyond a letter or number painted upon them, Fig. 57, which at a distance is not discernible. In some a better plan has been adopted, that of affixing to the arm a large letter projecting above and below, such as an S or O, Fig. 58; or as in the case of the signals recently erected at the Ludgate Hill and Holborn Viaduct Extension, where figures are attached to the end of the semaphore arms and projecting distinctly therefrom, Fig. 58*a*.

To distinguish the main-line signals from junctions on the Great Western, double discs, bars, and lamps are adopted, the upper ones being somewhat smaller than the lower, Figs. 59, 60, 61. At Victoria Station, in addition to the semaphor-

arms, similar to Figs. 46 to 50 *ante*, circular lettered or figured discs are used with great advantage; at night and in dull or

FIG. 57.

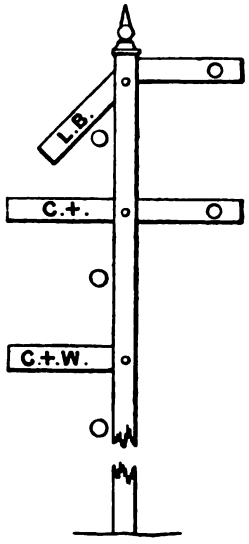


FIG. 58.

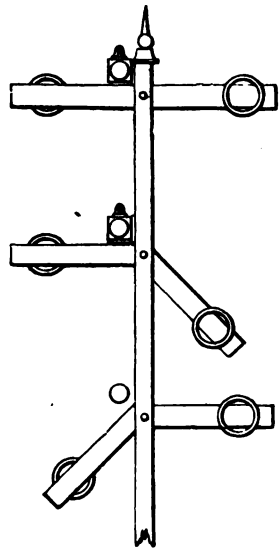


FIG. 58*a*.

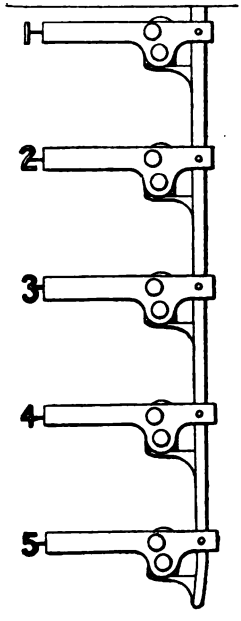


FIG. 60.

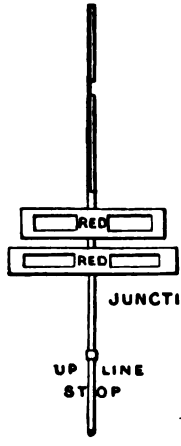


FIG. 59.

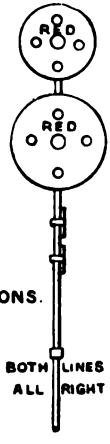
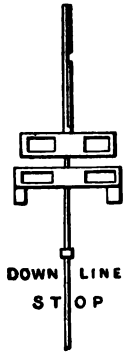


FIG. 61.



02

foggy weather, these discs have gaslight reflected upon them from a lamp fixed at a suitable angle. The method of working the traffic is nearly as follows:—When a train arrives at the distributing signals, having been admitted inside the home signals, and the arm corresponding to the road occupied is lowered for the driver to proceed, a disc is simultaneously raised showing the number or letter of the next signals (sometimes several in succession) for which he is to look out, and which pass him into the platforms; for instance, the station signalman indicates to the next signalman outwards the number of the platform safely approachable for a certain train, and he sets his signal and points for such a combination of cross-over roads which cannot be meanwhile fouled by any other trains, and the driver must not proceed unless he sees the arm lowered corresponding to the letter by which he was admitted upon that stage of his progress.

At Cannon Street Station the traffic is worked more simply; the trains are admitted into all the eight platforms by as many signals, but they are received and passed onward to these signals by two arms only, east and west, at the bridge end. The platforms are divided into four east and four west roads, and only one train to each set can be admitted together, but three may be passed out at the same time, *viz.* two to Charing Cross and one to London Bridge. When a driver is admitted to the Bridge signal, he has to wait until the arm governing his road, either east or west, is lowered, if it be not already so awaiting him, but he cannot safely proceed until one of the numbered platform-arms is also lowered, and although upwards of 600 trains are daily worked across from east to west and *vice versâ*, it is only on occasions of extreme pressure that any difficulty arises, and then mostly in consequence of the great amount of manual labour required to open and close the roads with sufficient expedition to avoid delays.

On the introduction of signals they were generally placed at the ends of the platforms, and the men in charge were frequently located some distance off, say at the station rooms or at a cabin having no pretensions to convenience, and whenever the signals required attention the men had to traverse a con-

siderable length of ground to reach them, and not only so, for in regulating the points they had in addition to run from switch to switch, many yards apart, often at the risk of their lives. One instance amongst many will suffice as an example. On the Great Western there is a goods yard and sidings nearly half a mile in length; the signalman, who was also pointsman, had to run the greater part of this distance along the balks or the stone and gravel ballasting, after turning his signal to danger, almost before the engine had passed it, to reach the points and be ready for shunting by the time the rear van had passed sufficiently beyond so as to clear them; the exhausting results entailed upon men working under such disadvantages one can readily imagine.

The first step towards an improvement on this state of things so universally prevalent, was by working the signals by wires brought close together, or at least within a few feet of each other; then attempts were made to work points at a distance by means of rods cranked and connected in long lengths, and ultimately Messrs. Stevens and some others succeeded in combining a series of point levers in one frame worked in a cabin or signal box, thus at once reducing the number of men requisite, and considerably lessening labour and chances of accident; but it remained for Mr. Saxby, in 1856, to inaugurate a new era in signals and points, by collecting the levers of both, and applying to them a system of mechanism for interlocking which would avoid to a great extent the possibility of error by giving conflicting signals, or signalling in direct opposition to the state of the points. These inventions have been constantly improved upon and advanced to a considerable degree of perfection by numbers of skilful and enterprising mechanicians, until there now exists systems of interlocking more or less good, but which, if studiously applied, can scarcely fail to be certain in effect, excepting only so far as that amount of reliance which must be placed in human fallibility is likely to lead into error.

PART II.

THIS leads under the second head to a brief explanation of a few of the most noteworthy signals which have been patented.

The necessity for an efficient and simple working of signals has afforded inventors a wide field for the exercise of their genius; and judging from the number of patents filed, irrespective of private inventions unpatented, they have not been idle during the last thirty-two years. On going through the whole of the specifications it is found that between 1841 and the past year upwards of 444 patents have been applied for and were sealed, or received provisional protection; the latter forming a very small proportion, which were doubtless not completed, owing to their too close resemblance to previous patents.

The numbers for each year are as follows:—

OLD LAW.	
1841	3
1845	1
1846	1
1847	3
1849	1
1852	2
NEW LAW.	
1852	5
1853	33
1854	15
1855	13
1856	25
1857	20
1858	12
1859	14
1860	9
1861	23
1862	15
1863	14
1864	15
1865	21
1866	26
1867	18
1868	22
1869	18
1870	22
1871	31
1872	35
1873	27
	444

The first signal patented (Figs. 62 to 64) was by Berwick Curtis, in January, 1841, and it consisted of a cross-bar or disc placed on a mast, or to exhibit from behind a screen; it might also be affixed to the face of a bridge or tunnel, and was actuated by the passing train depressing a lever, which set a system of clockwork in motion, raising the signal arm or disc from behind a screen, or turning it to danger; the contrivance required winding up at intervals, and would pass fifty-four trains, but could be constructed to accommodate a greater number.

The method of working was as follows:—A piece of wood *a*, having the lower surface curved, was fixed to the locomotive

FIG. 62*a*.

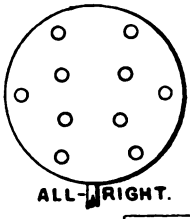
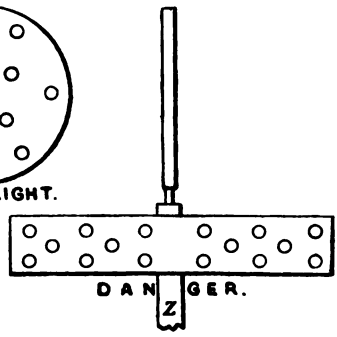


FIG. 62.



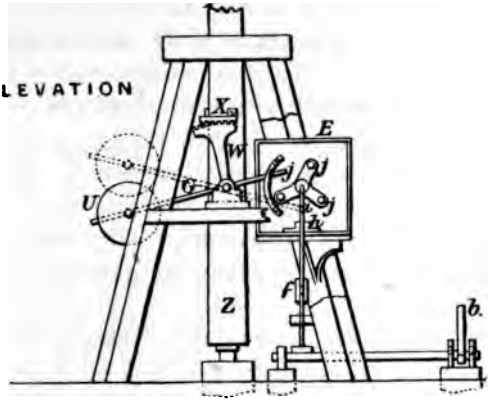
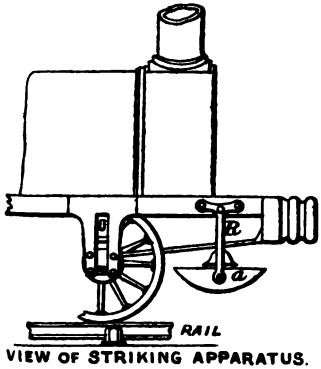
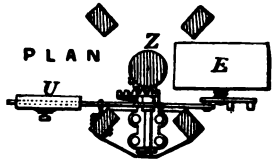


FIG. 63.



VIEW OF STRIKING APPARATUS.

FIG. 64.



framework near the buffers by means of an iron bar R; in passing along the railway this bracket came in contact with a trigger *b*, depressing it, causing the vertical rod *f* to descend, by which the link *h* withdraws the goose-neck end of *i* from its contact with the central part of the radial arms *jjj*, which is instantly set in motion by the wheelwork in box E, and on moving round lifts the weight U on the lever G, causing the toothed sector W engaged in the quadrant X to revolve, and so turn the mast Z to danger. To ensure the return of the goose neck a spring is applied behind it, and there is also a spring attached to the radial arms, which presses them forward along the axis on being released by the goose neck; the signal is returned to its normal condition gradually by the clockwork. Curtis was also the inventor of a self-acting switch, connected to an indicator, very much used by many companies, and first adopted in 1838.

During the succeeding period of eleven years only nine patents were granted, and those mostly for signals actuated by a lever or treadle being pressed down by the passing train. In 1852 the new patent laws were brought into operation, thus giving a fresh impetus to inventors, and immediately the numbers greatly increased, showing an annual average of twenty sealed patents.

In November, 1852, J. Crowley patented a self-acting electric signal, successively set to danger, and released by the passing train breaking an electric current constantly kept up. He proposed that the normal state of the semaphore arm should be caution instead of all right, thus reducing the arc through which it should pass to the least dimensions, *viz.* 45 degrees.

Three patents, in 1853, are worth notice—that by C. F. Whitworth, dated 28th January, consisting of a double disc, or spectacle-turning signal; it was set to danger by the trains, and returned to "line clear" afterwards by the signalman.

F. Boake patented the first iron signal mast in April; it consisted of angle irons and lattice bars riveted together, fitted with chains and winches for hoisting the lamps and india-rubber cushions at the bottom to receive them when lowered. In October, John Cashmere proposed an extraordinary plan, that

of laying a gas-main from end to end of the line of railway with branches and burners; in case of an accident the guard could open the cocks and increase the light of each jet beyond and in rear of the train, and so give warning in both directions.

In 1854 the following are some of the inventions patented: one by James Stevens, in February, a mechanical arrangement by which the semaphore arm was balanced to give the three signals and to answer for day and night by the same motion; this was the first of an important series of improvements made by the firm of that name. Fig. 65: A is a weighted lever, connected by a rod with the arm and lamp. The lever is actuated by one of the levers R or S and the wire and chain connection *f*. The drawing shows the signal in its normal state. The caution signal is thus produced: the levers R, S, must be moved to the position R^1 S^1, lifting the lever A to the position A^1, where it will be retained by the stud fixed to the apparatus on the lever A, which is brought into position by the stud *d* on the small lever. When the all-right

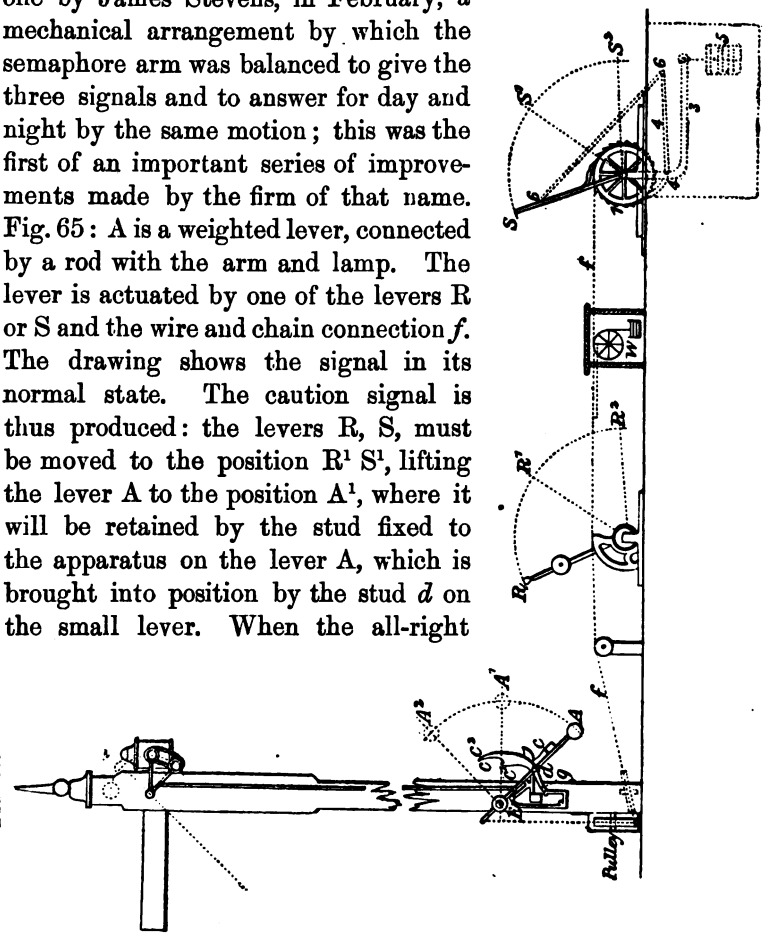


Fig. 65.

signal is to be given the levers R, S, must be still further moved to the positions R^2, S^2, which will similarly move the lever A to A^2, with its shorter end resting on the stop E, when the apparatus may be returned to its original position.

To give the danger signal, the stud on lever A during the return movement passes over the surface c^1 on lever c, the lever A being meanwhile supported by the projection g. The chain or wire is attached to the periphery of the ratchet 1, turning freely on its axis; S is a lever acting on the ratchet wheel, which is retained in position by the weighted lever 3. This lever has a pawl 4, which takes the teeth of the ratchet wheel, so as to retain it in its position when pulled over by the operator. 6 is a chain connecting the lever and pawl, in order to release the pawl for the return movement.

In March, by Greenwood and Saxby, for enabling one lamp on a semaphore mast having double bulls'-eyes to give signals in both directions, the coloured glass moving before the light inside the frame.

C. Forster, in 1855, patented a novel invention; it consisted of a lamp fixed on the engine to face the driver, having coloured glasses and a movable flap. When a signal was to be given the signalman would raise a treadle attached to the rails, so that the lever on the engine would be struck, and an indication given by the lamp or flap. In case of accident the guard could go back a distance, and fix a portable treadle to the rails in such a position as to warn a following train.

In January, 1856, F. Lankestier invented a system of pipes, containing water with a solution of salt to prevent freezing; these were to extend along the whole length of railway; the engine, on passing a certain point, would depress a lever, actuating a piston in the pipes and causing the signal to be raised by hydraulic pressure. J. Fenton, in October, proposed the following unique mode of ascertaining when a driver passed a danger signal: a small phial, containing a liquid, was to be placed on a projection of the signal arm when at danger, so that if an engine passed it, it would strike the phial and spatter the liquid over the buffer beam, thus affording a supposed proof of the rules being violated. On the 19th December John Saxby's first important invention was patented, and led the way to the present system of interlocking; the signals and points being worked together by one lever and cranked connecting rods, but capable of being worked separately; if desirable, a

raised stage, so as to afford the signalman a better view of the roads under his control, was adopted; also a simple method of locking points.

The patents for 1857 and 1858 were mostly for engine-worked signals actuated by electro-magnetism variously applied.

In October, Saxby invented a signal which could be set to danger by the engine depressing a lever, at the same time ringing a bell in the signalman's cabin, but the signalman would have to release it; the form was that of a double disc on a fixed post balanced to rise and fall on its centre; the distant and home signals at junctions were connected and interlocked so as to prevent contradictory indications being given.

For 1859 three inventions may be selected, being by J. Stevens, E. W. Scalè, and Joze Luis: the first consisted of an iron mast formed of angle irons and flat bars bent from angle to angle and riveted thereto; slide rods were provided for hoisting the lamps upon, and a method of compensating for the expansion or contraction of the signal wire by a weight affixed to the pull-over lever free to run up and down when in its normal state, but tightly gripped at the commencement of the movement to pull over.

The second, dated in May, was a pneumatic collapsible coloured bag or signal; the wheels of a train in passing would press down a lever communicating motion to an air-tube piston which would force air into the bag for a given time; and the third was a plan by which a signal when given would repeat itself in the signal cabin; it was effected by an endless wire upon two pulleys attached to the signalling disc and to that in the cabin.

During 1860 few patents were taken out, and those were principally for signals actuated by electricity: one by William Bull, in October. He proposed to make the rails the conductors of the current, so that the train could at certain points be communicated with, or the guards or driver could do so with another train or station; portions only of the rails would be insulated, and an indicator on the engine would show when those portions were being traversed and also register the distance travelled.

Austin Chambers patented a locking apparatus of a simple kind, and arranged so that the signals might always stand at "danger." 1861 brought a considerable number of inventors forward, chiefly with plans for various kinds of self-acting signals actuated by treadles or levers. C. F. Whitworth improved his former invention by adding a cranked arrangement to prevent jar to the arm in falling, and breaking the lamp shades.

Whitaker and Jones, of Aylesbury, proposed a plan for registering the state of a signal by means of an arm coming in contact with a wire through which an electric current was kept up; the same wire was used to work the signal from the cabin.

A point indicator was invented by W. G. Laws in December: the points were attached by shifting bars to the arms of the signal, so that when the points were truly set the white arm or green light would be visible, and when not properly set the red light would be seen.

A similar patent was brought out by J. Stevens in 1862, known as the quadrant indicator; it is very much in use, and has been described in the previous section, Figs. 41, 42, 43.

In March, Martin A'Becket invented a revolving signal, consisting of two cones painted black and white, placed base to base, and held through their centres upon a pin and free to move; when a train passed the cones would be caused to revolve quickly; if a following driver found them in that state he would know that a train was not far ahead; if they were revolving slowly he might proceed cautiously, and if stationary, at the ordinary speed; at night a light would be placed so as to reflect its rays directly upon the cones.

Samuel Partridge, in July, and John King, in December, introduced time indicators having dial faces divided from 0 to 15 minutes; the pointer was set in motion by ordinary clockwork, the action of which was released by the passing train. A lamp at night would throw a light upon the face of the dial.

The first invention for connecting crossing gates and signals so that they might work in both directions simultaneously, was patented in March, 1863, by C. H. Lea.

In July, 1864, W. Anderson brought out a system of locking apparatus upon the principle of the Jacquard loom, that is, by selection; the levers were connected to the signal and points by sliding rods, and each bar was attached to a selecting lever which moves on the face of a quadrant having notches indicating the systems to be worked. The selecting lever shifted the pierced transverse sliding bar, bringing certain holes of that bar into coincidence with certain rods, leaving them free to move through when acted upon by the operating lever. In August, J. S. Farmer patented an improvement in iron signal masts, adding iron ladders, and placing the signal light on a level with the semaphore arm; he also proposed tubular masts with a means of hoisting the lamp inside.

The patents for interlocking points and signals form the principal feature in improvements during succeeding years; and in 1865 the following may be noted: one by R. Bell, in March; his plan was such, that no points could be worked until both distant and station signals were set to danger: the movements depended on a leading lever; each lever unlocked and back-locked its fellow in succession, and must be so moved; the levers being locked high up prevented the signalman from springing any one of them. Another by W. H. Preece, in August, to prevent a signalman from giving "line clear" until the train had passed his box; the switch or signal would be locked, and only released by the passing train actuating an electric apparatus.

Messrs. Walker brought out an electro-magnetic signalling apparatus, which has been used for many years upon the South-Eastern Railway with great success: it consists of a miniature semaphore and bell fixed in the cabins and worked by a single electro-magnet, and requiring only one wire for the up and down line; its use establishes the "block system," for so long as the red arm L is kept at danger by the signalman at the next cabin, a train must not be sent forward; the white arm M is a repeat of the position of the corresponding arm as it is placed by the man when he signals to the next cabin and fixes the arm there. The working is thus: when a train is ready to start or is advised, the signalman causes the bell at the next station to

ring a number of pre-arranged times; if the line is clear up to that station the man there replies by a ring and lowers the telegraph semaphore at the station at which the train is waiting; when it has left, another ring is given forward and the arm is once more fixed at danger. Fig. 66 is the semaphore

Fig. 66.

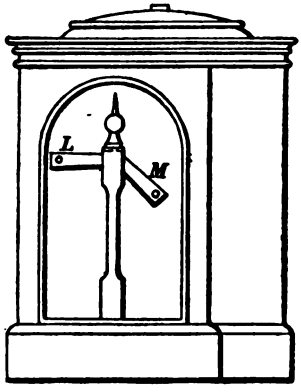


Fig. 68.

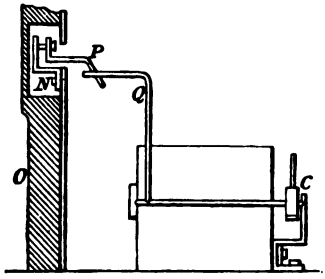
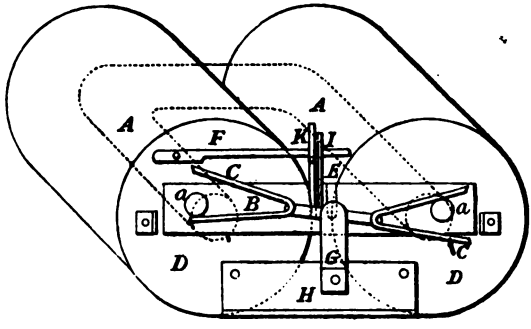


Fig. 67.



and case; Fig. 67 shows the arrangement of the magnets. A electro-magnet, *a* the poles, B the armature, C permanent V-shaped magnet pivoted on a cock G carried by a brass plate H; the ends of the poles are covered with wooden caps to prevent actualcontact between the two magnets; a spring F is also fixed on the face of the coils D, and on the base which carries the whole arrangement. The pin I has a to-and-fro movement imparted to it by a similar motion of the magnet C; it is shown

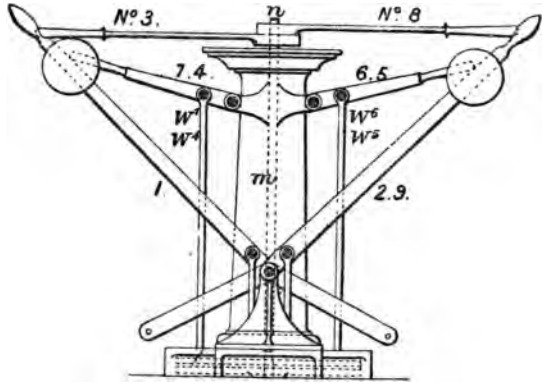
as held in a certain position by the cam or stud K. The side view, Fig. 68, shows how the movement is transferred to the visible index; the arms are carried by a cock N, a light bent wire P is fixed to one end of the arm passing through the face of the dial and resting upon the wire Q, which is connected with the magnet C. When the position of the system of the latter magnet is changed, the wire Q is removed and the arm falls, and when the magnets are again changed the wire Q forces the wire P with the arm into its original position.

Among the patents of 1866 is one by J. Brown, dated 7th May, for interlocking; his novelty is in the arrangement of the sliding bars and oscillating rods above them in connection with hinged pins dropping into holes of the sliding rods or bell cranks, whereby the locking and unlocking is effected. By McKenzie, Clunes, and Holland, in July, for maintaining the point close up to the rail without any adjustment of the lever rods by means of a "duplex switch balance:" for the purposes of locking they adopted in addition to the ordinary lever a rocking lever on another fulcrum, so that when the signal lever is thrown over, a stud traverses a slot or arc, and prevents the point lever from being moved. Another plan by Livesay and Edwards in August, by which the heads of the lever handles would be held by a weighted balance and eye, so that when locked they would be fully under the notice of the operator. An invention by Deas and Rapier in November, for a stop block, consisting of a sole plate on a hinge, with an angle-piece at the end so inclined that in a gradual manner it would guide the vehicle off the rails and so prevent its travelling on to the main line. In the same month Clements invented a miniature signal to be fixed on the engine boiler fronting the driver, and actuated by a lever attached to the rails, and connected with signals in advance, thus giving notice to the drivers of their state.

In 1867 improvements in locking apparatus formed the majority. First, may be noticed a plan by I'Anson and Kitching: the locking was effected by means of a crank having an elongated hole covering, or releasing a pin. Next, a series of arrangements by Saxby and Farmer in February: their specification is very elaborate, and is one of the most complete of the whole of

the signal patents; the details occupy some thirty pages of letter-press, illustrated by eleven sheets of drawings; they do not so much introduce entirely new principles of mechanism as to apply those previously patented to more extensive systems of branch and crossing lines, such as are requisite for the working of complicated termini. One feature, however, deserves special notice: to economize room in signal cabins they contrive a horizontal motion of some of the parts instead of a vertical, and a rectilinear for a rotary motion; this is effected by circular stop plates, instead of rods or bars, furnished with holes or slots, and worked on an upright hollow standard, not unlike that of the disc switch in use on the Great Western. Figs. 69 to 72 illustrate the vertical motion of the locking. In this arrangement

Fig. 69.



Elevation.

there are circular stop plates, AB^1 AB^2, one of which is fastened to the bottom of the vertical shaft *n*, moved by the point lever No. 8; the other upon the hollow shaft *m*, enclosing *n*, and moved by the point lever No. 3.

These two point levers describe here areas of circles in a horizontal direction, as will be easily understood, and the rods working the points themselves are fitted to the bottom of the solid or hollow shaft respectively. The circular plates AB^1 and AB^2 are furnished with slot holes, or with notches in the edge corresponding to the holes or slots in the stop plates, Figs. 71 and 72.

Each signal lever is connected to a vertical rod W, worked in a manner similar to a horizontal apparatus, but in combination

FIG. 70.

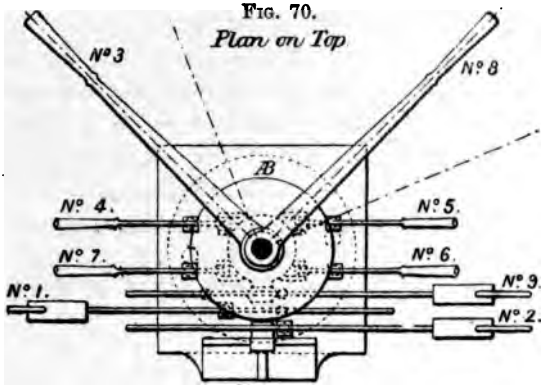


FIG. 71.

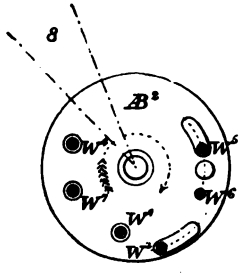
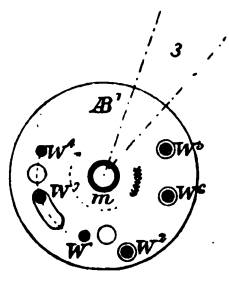


FIG. 72.



with the point levers Nos. 3 and 8 in their respective connection with the stop plates A B¹ A B², which they work. Figs. 73 to 77 explain Messrs. Saxby and Farmer's horizontal apparatus as generally erected by them. The following schedule shows the duty of each of the levers:—

Lever 1 actuates the distant signal of up branch line 3.
" 2 " " " main " 1.
" 3 " points of up lines 1, 3.
" 4 " station or junction signal of up branch line 3.
" 5 " " " down main line 1.
" 6 " " " " " 2.
" 7 " " " branch " 4.
" 8 " points of down lines 2, 4.
" 9 " distant signal of down lines 2, 4.

This arrangement is for nine levers with three slides, one over the other. Fig. 74 is a vertical section across the frame;

the slides are marked A^1 A^2 A^3, each of which is connected with a certain number of main locks. Fig. 77 shows slide A^1 in plan, with locks and pins.

FIG. 73.

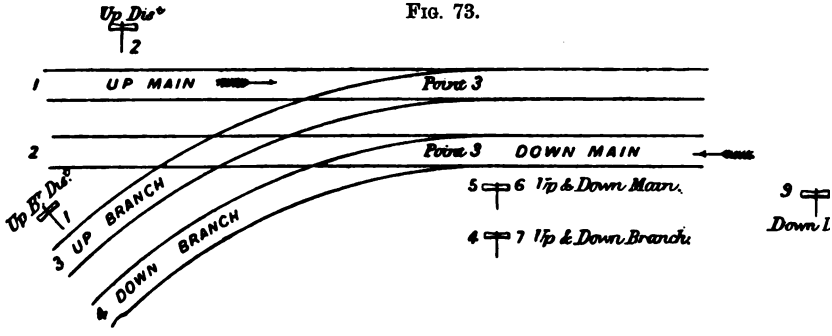
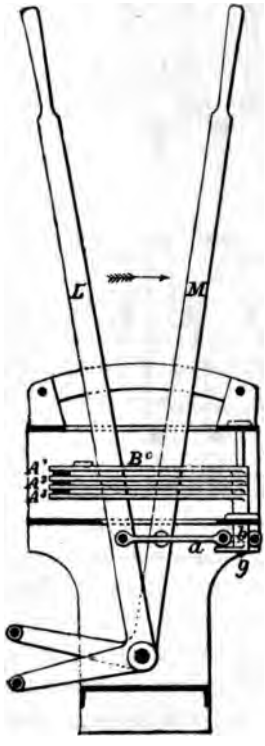


FIG. 74.



Figs. 75 and 76 similarly show the slides A^2 and A^3, and the whole of the levers are indicated only in Figs. 75 and 77, where they are numbered in accordance with the schedule. In Fig. 74 the two point levers only are shown in elevation; the lever L being closed, or in its extreme position towards the front, and M open, or in its extreme position towards the back of the frame.

If the lever L is moved in the direction of the arrow, the forked lever *a* connected to L is set in motion; *a* again actuates the cranked lever *b*, one arm of which is connected with the forked lever *a*, whilst the other bears upon the concave surface of the lever arm *c*, and causes the latter to vibrate on its fulcrum *d*, in either direction; the other arm of the lever *c* bears by means of a fork piece upon a pin *e*, fitted respectively to the top or bottom surface of any one of the slides A. The motion

of the hand lever L being thus communicated to the straight lever *c*; the latter in its turn imparts a longitudinal motion to the slide *a*.

FIG. 75.

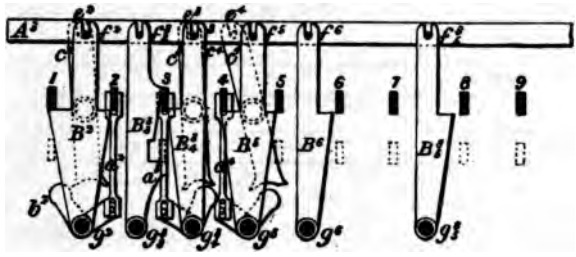


FIG. 76.

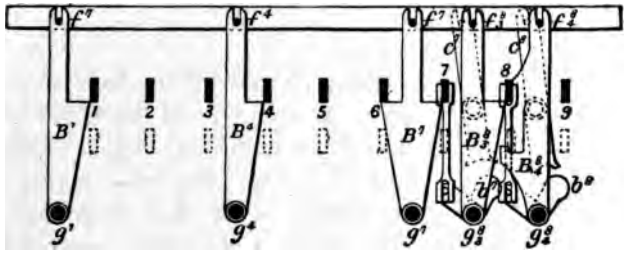
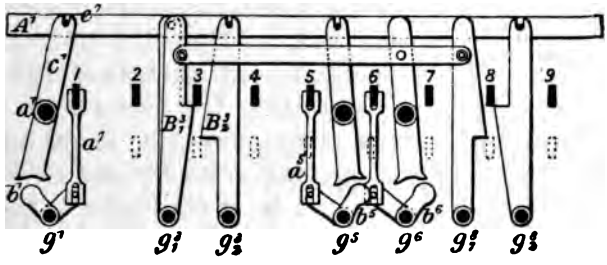


FIG. 77.



The slides A are fitted with another series of pins *f*, fitting into the fork-shaped heads of the locks B, which are thus caused to describe arcs of circles in pivoting upon their axes *g*. The locks B are iron stop plates cut at right angles, upon one side of which the respective hand lever bears when it gets into a certain position, which, it will be readily understood, takes place upon the locks partially revolving or pivoting round their axes *g*.

The inclined sides or planes are intended to assist the other mechanisms, seeing that the hand lever bears upon such an inclined plane if its open position is converted into a closed one, and thus the shutting of the levers is facilitated and accelerated. The general effect may be thus explained:—

By opening the lever No. 1, then No. 3 is locked in its open, and No. 8 fixed in its normal position.
By opening the lever No. 2, No. 3 is locked in its normal position.
By opening the lever No. 3, Nos. 2, 5, and 6 are locked in their normal positions, and Nos. 1 and 4 unlocked.
By opening the lever No. 4, No. 3 is locked in its open, and No. 8 in its normal position.
By opening the lever No. 5, No. 3 is locked.
By opening the lever No. 6, No. 3 is locked, and 8 in its open position.
By opening the lever No. 7, No. 8 is locked.
By opening the lever No. 8, Nos. 1, 4, and 7 are locked, and No. 6 unlocked.
Signal lever No. 9 not being connected with the points is omitted in this schedule.

FIG. 78.

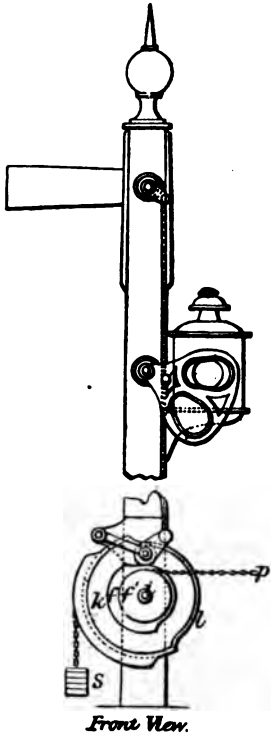
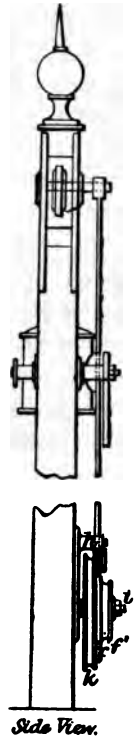


FIG. 79.



Figs. 78 and 79 show a method of actuating repeating signals when the distant is too far off to be ordinarily visible to the signalman. The operator, working in his cabin upon the distant signal lever, sets a wire in motion, one end of which is connected to the apparatus in the cabin, whilst the other is fastened on a cam *f*, the periphery of which is shaped to correspond to the duties assigned thereto. This cam consists of a pulley or roller f^1, upon which bears the chain *p*, and the wheel proper *f*, on the flat portion of the circumference of the latter bears a small roller connected with the cranked lever *h*. The wheel *f* re-

volves freely upon its axis *i*, fitted to the side of the post, and by the partial revolution of the wheel *f* the cranked lever *h* is acted upon, and one arm of this lever acts by a rod upon the semaphore and lamps. Suppose the cam wheel to describe a limited arc of a circle; the signal denotes caution, and the chain *p* may be pulled as soon as the signal has spoken. If the lever in the box is closed, and the signal denotes danger, the weights S cause the cam wheel to turn, being attached to the circumference of the pulley K, which revolves freely on the axis *i*; and to maintain the distant signals at danger as a normal condition, the pulley K is furnished with a ring, projecting upon its side, upon which bears the axis of the lever *h*; and by the action of the weight S the danger position of the semaphore is preserved, as the lever *h* can act only if the axis of the lever *h* is displaced by the motion of the wire *p*. By this plan one wire will actuate both distant and repeater signals.

Livesay and Edwards invented a plan by which a train locks the points while passing over them, thus preventing the signalman from moving them, or the train from springing them open; the locking is made by a bar fixed under the rail, which on being pressed down catches a stop. W. Easterbrook proposed an improvement by increasing the length of the spring hand-levers behind the main levers, so as to pass underneath the catches set on the rocking levers; when a lever is brought into position and the spring lowered into its notch, the rocking levers bring over on to the tee terminations of the spring levers, the respective hooks; this was subsequently amended by the introduction of two rods instead of one parallel to and connected with the main lever; the locking was complete directly the double spring lever was lifted and immediately before the main lever was moved.

Wilkins and Clark, in their specification of the 17th October, proposed that the semaphore arms should be gilded instead of painted, as affording greater distinction.

Mr. Francis Brady, C.E., patented an apparatus considerably used on the South-Eastern Railway; he adopted pin-jointed links on rods, one link to each lever; the rods at intervals were pin-jointed to the ends of the short levers, the sides of

which abutted upon the sides of the stops fixed on the spindle of the switch lever, thus locking it. Fig. 83 is a supposed plan of a junction, Fig. 82 an end view of the apparatus, and Fig. 81 the front elevation of the same; Fig. 80 plan of locking axes.

FIG. 80.

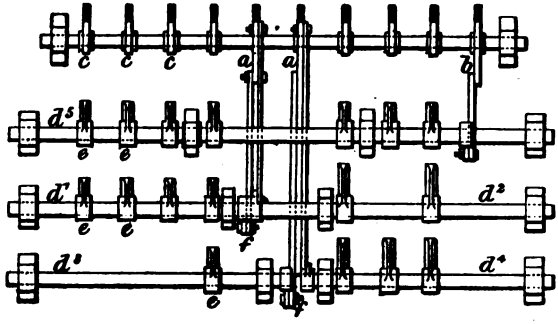
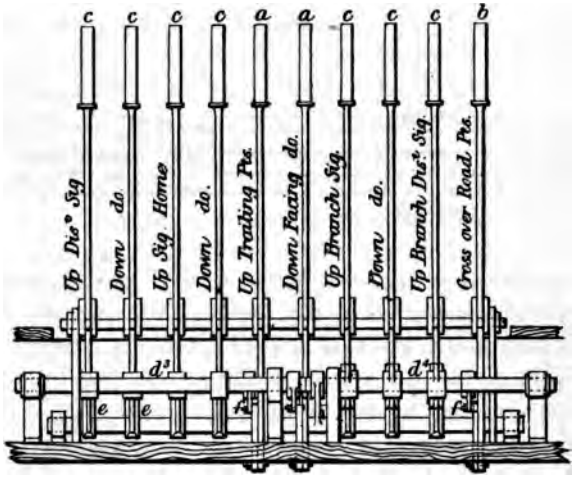


FIG. 81.



a, *a*, are the two point levers of the main and branch lines; *b* is a lever which works both the points of the cross-over road; *c*, *c*, are levers connected with the several signals, having the names of the signals or points written upon them; d^1 to d^5 are horizontal spindles on which the locking axes *e*, *e*, are fixed; *f*, *f*, are the moving cranks. They are shown in the position

they occupy when the main lines are open and the branch closed.

To each of the signal levers c there are jointed horizontal bars c^1, which are connected by links c^2 to the floor by means of shoes, in which the short links turn; the links so connected with each signal lever are always parallel to the lever, and against them, and against the levers the locking axes on the horizontal axes

FIG. 82.

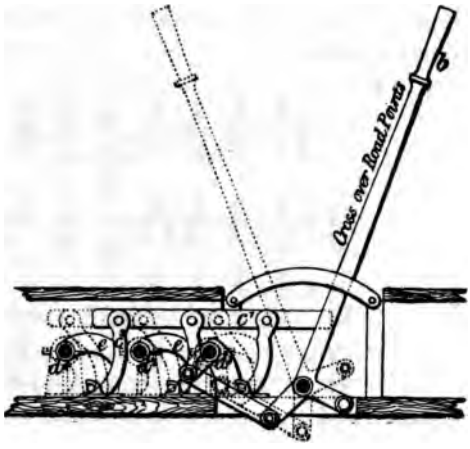
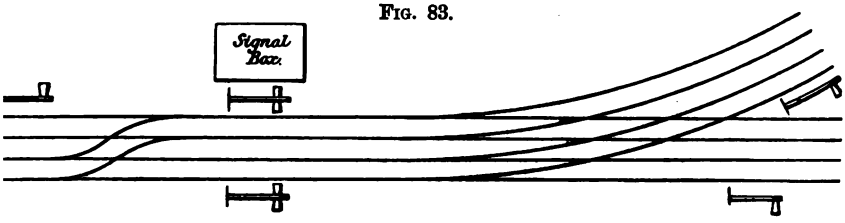


FIG. 83.



act. In the drawing the signal levers are as standing at danger, and consequently the point levers are all free. If the trailing point lever is moved from its present position to a position to suit trains coming from the branch on to the main line, it, by means of links connecting it with the arms f, on the axes d^1, d^2, causes these axes partially to rotate, and in so doing it removes the locking axes from the links c^2 of such of the branch signals as may then be lowered, whilst at the same time it moves other locking axes c in front of the links c^2 of the main-line signal levers, which require to be held at danger. In a similar way the facing point lever, when moved over to suit trains entering on the branch line, gives motion to the axes d^3, d^4, and by means of the locking axes

upon them unlocks such of the branch signals as may require to be lowered, whilst it locks any of the main-line signals which require to be then maintained at danger. The point lever *b* of the cross-over road, when moved over, closes both the points of the cross-over road, and at the same time causes the axis d^5 partly to rotate, and brings up the locking axes thereon so as to lock all the signal levers at danger.

This system is applicable at junctions where a greater number of point levers is required, each point lever in the manner described being caused to give motion to a separate axis or axes, with locking axes thereon to lock and free the signal levers.

Among the patents of 1868 are two by J. Cashin, the first in April, for an arrangement to enable a shunter to set or lock the points in the normal or abnormal position, as necessity may require; and the second in October, for enabling trains to pass behind the points, and to open them without disarranging the locking gear; the points could be set by the ordinary wire ropes instead of iron rods.

A system invented by Wm. Baines will be best illustrated by giving a description of the working at the Lindal Cote Junction. Fig. 84 shows a plan of the junction; Fig. 85 shows the elevation of the lever frame for eighteen levers; Figs. 86 to 88 represent the rocking shafts G and main shafts F in various stages during the pull over.

This junction is somewhat complicated, it having a cross-over road running into both up and down main lines, two branch lines M N on one side, and three lines P Q R on the other. There are catch points at S on the up side, which have to be kept closed for the cross-over road, and open for the catch siding T, so that the main lines may not be fouled by traffic on the M and N lines; these catch points can only be opened for the cross-over road when the signals have been set to danger for the main lines and the branch lines on the opposite side; consequently nine points and seven signals have to mutually interlock with one set of points at S. The levers are all centred on the shaft F, and above this is the shaft G, which passes through a quadrant arc in the foot of each lever A, thus allow-

ing the required range of motion. On the shaft G are loosely slipped a number of short tubes or rockers J; these have cams

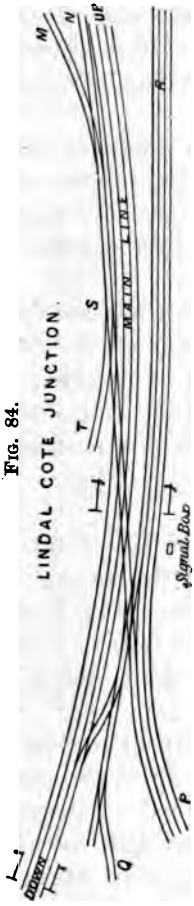


FIG. 84.

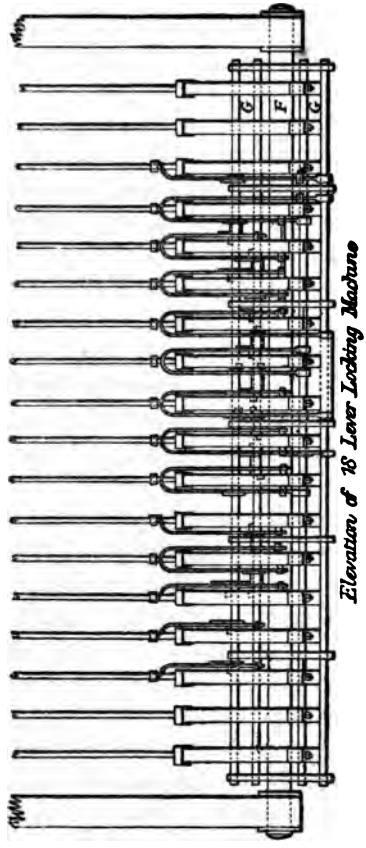
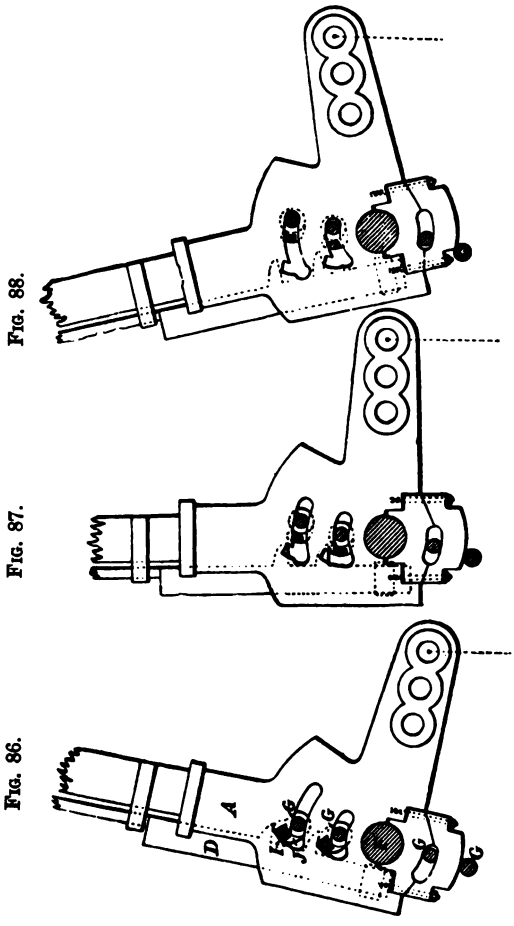


FIG. 85. *Elevation of 18 Lever Locking Machine*

upon them which act against projecting tappets, fixed one upon the bottom of each rocking bar; and when the cam is kept up under one of these tappets it prevents the bar from being pushed down, in which case the detent of that lever cannot be raised out of the quadrant notch. The practical result of this arrangement is, that before the lever has been moved $\frac{1}{8}$th inch in the quadrant, the locking of the second

lever is perfectly effected; the pressure upon the several parts is very small, and they do not require oiling.



In 1869, C. H. Lea further improved his plan of March, 1863, for the simultaneous working of crossing gates and signals.

In April, R. C. Rapier invented a means of locking without any moving bolts, cranks, screws, or claws. The pointsman could easily see which levers might or might not be moved. A bar is mounted on the point levers extending between the

signal levers, dividing them into sets, and as respects each point lever in motion either way separating the signal levers, which must precede the point levers in their movements from the others. The levers are all arranged in a frame, in the usual way; one side of the frame is termed permission for main line, and the other permission for branch line. On each point lever is fixed a bar, the bar on one set being lower or higher than that on the other, extending as above described, and so coupled with the signal levers that if there be arranged on that side of the frame called permission for branch line all those signal levers belonging to the main line, and on the opposite side of the frame those signal levers which belong to the branch line, all the signals will be then at danger, Figs. 89 and 90.

FIG. 89.

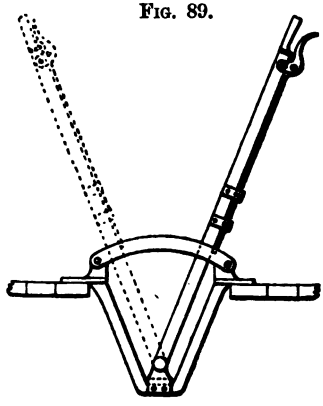
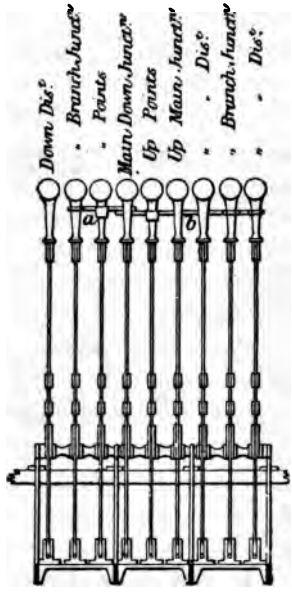


FIG. 90.



The bars on the point levers extend over the point levers in such a manner that on either point being brought over to one side of the frame, the bar upon it rests against those signal levers which ought to be locked by it when in this position,

and the signal levers which are ranged on the other side of the frame are no longer locked by this lever.

The side of the frame which gives permission to the main line gives danger to the branch, and the reverse; but in no case can the signal levers be moved before the point levers.

During 1870 the following inventions were brought out: by Saxby and Farmer, for ensuring a close contact between the point and rail; by means of a reciprocating bar on vertical radii, connected with the signal and point lever, and of greater length than the wheel base of two couples, which locks the point during the passage of a train, and cannot be moved by the signalman.

In March, by J. Stevens, to ensure a certain order of movement of the levers, so that a signalman could be left no choice of procedure, but must lock and unlock upon a pre-arranged rotation.

W. Smith, in April, proposed the adoption of treadles in connection with the levers, to be depressed before the latter was free to be pulled over.

W. H. Preece and Langdon invented a method of locking the signals at a distant station by means of electro-magnetism, so as to maintain the absolute block system in addition to the telegraph semaphore; and R. C. Rapier another, for locking improvements, each lever having a sector struck from the centre of the fulcrum of the lever; the locking and unlocking at various points on the periphery of the sectors by bars extending across them; also a plan by which the movable point locking rail is raised vertically before it can be traversed, thus preventing a signalman from moving the point while a train is passing over it.

Among the inventions of 1871 is one by J. Bonchetti, consisting of an appliance by which when a signal was raised to danger an arm would be projected so as to strike the flange of one of the engine wheels and make an impression of a letter or figure, indicating that a danger signal had been passed; and another by F. M. Sims and S. H. Yockney, so that when a signal was set to danger an arm would project from a bracket affixed to the head of a post erected by the side of the rails in a position to strike a lever fixed to the engine chimney, and connected with

a gong, bell, or the steam whistle on the engine; the mechanism was such that the impact upon the lever when struck would be very slight, but the effect certain.

The patents in 1872 were very numerous, but few invite special consideration; a large proportion were for signals and points actuated by electricity, and that by Barlow and Carr may be usefully explained somewhat in detail. Their apparatus is so contrived that the train announces its approach to the signal cabin, that a signal is telegraphed on to the train by the signalman, and the signal so received is repeated back to the signalman. In order to carry out these arrangements there is a warning signal in the signal cabin that the train may announce its approach. This signal is given by the wheels of a train acting upon a contact-making apparatus situated at suitable distance from the signal cabin. The contact-making apparatus is formed by preference of a spring which is pressed down by each wheel of the train as it passes over it, and thereby moving a contact maker. An insulated wire is laid from this contact maker to the signal cabin, and there connected with an electro-magnetic instrument so arranged that the passage of each wheel over the spring causes one stroke to be given on a gong or bell. The signalman being thus warned of the train's approach transmits a signal to a signal instrument on the train. To enable this to be effected there is in the signal cabin an instrument for transmitting the required signal to the train. This instrument is a simple arrangement by which the signalman by a contact maker of the ordinary construction can break or couple-up the current from a battery in the cabin to an insulated wire. This wire is laid from the cabin up to an insulated metal surface placed in the line between the rails at a suitable distance from the signal cabin. The insulated metal surface is not permanently in electric connection with the insulated wire from the signal cabin, but is thus connected at the time that a train moves over it. The insulated metal surface may be a roller supported by a spring, and having a contact maker below it enclosed in a suitable box and coupled-up with the insulated wire from the cabin. In this case a curved metal bar carried by the engine may act

upon the roller and depress it, so as to put the roller and bar on the engine in electric connection with the insulated wire, or the insulated metal surface may be a bar fixed parallel with the rail, and a roller or spring be mounted on the engine so that it shall come into contact with it. In this case, in order to put the insulated bar in electric connection with the insulated wire at the time when a train is moving over it, the wheels of the train would act upon and depress another metal bar placed close alongside one of the rails. This bar is mounted on a number of short links, and is held up by a weight or springs. The axis of one of the links forms part of a contact maker enclosed in a box. The contact maker is constructed so that when the bar is held up the insulated wire and insulated bar are not in electric connection with one another; but when the bar is depressed by the wheels the contact maker completes the connection between the wire and insulated bar. The spring or roller which is mounted on the engine, and which comes into contact with the insulated bar, is coupled by an insulated wire to the end of the coil of an electro-magnet forming part of the signal instrument upon the engine. The opposite end of the coil may either be coupled to any suitable part of the engine, so that the connection to earth may be completed through the lines of rail, or the return current may be conveyed back to the signal cabin by a second insulated wire connected like the other wire to a contact maker to be moved simultaneously with the other contact maker and by similar means. The instrument on the engine is made with a movable signal disc, arm, or other contrivance, which remains in its normal position until an electric current passing from the signal cabin to the electro-magnet above mentioned moves it. When the signal disc or arm is in its normal position it represents the signal "stop," and when it has been moved to the other it represents another, "go on." If a current passes through the instrument on the engine, the signal is moved to "go on;" if no current passes through, the signal remains in its normal position and represents the signal "stop." The stop signal carried by the disc or arm is a red glass, and the go on signal a white glass. When the signal disc or arm is in its normal position, the red glass will be seen

through an aperture in the front of the casing of the instrument. If the signal disc or arm is moved to "go on," the red glass is moved away, and the white glass comes behind the aperture. The instrument is made so that a lamp may be placed behind the signal disc or arm, in order that at night a red or white signal light may show. In front of the signal is a screen, which, as the engine passes the insulated metal surface before mentioned, is moved away mechanically or electrically by a trigger or spring fixed on the engine, and at the same time a bell is rung to attract the attention of the driver to the signal exhibited. As soon as the driver has seen the signal, he, by depressing a finger-key, replaces the screen in front of it, and in so doing puts back the signal disc or arm (if it has been moved). This putting back the screen may be done either by the engine driver or by an automatic arrangement; but it is preferable that the driver should, as a part of his duty, be required to put the screen back to its normal position. For repeating the signal received in the instrument on the train back to the signal cabin there is on the engine an arrangement that when the disc or arm is moved a contact is by the movement of the disc or arm caused to be made between the extremities of the two wires, one coupled to "earth," and the other put into electric connection with an insulated wire leading to the signal cabin by means of apparatus similar to that already described, and situated at a distance of about twenty yards from it and nearer to the cabin to which the train is approaching. In the cabin the insulated wire above mentioned is attached to a similar instrument to that on the engine, so that if the signal disc in the instrument on the engine is moved, the disc in the instrument at the signal cabin will be moved also, and *vice versâ*. Thus the signalman at the cabin knows what signal the engine driver has received. In connection with the instruments in the cabin there may be a register so arranged as to register the signal given by the gong, the signal given by the signalman, and the signal repeated back from the train. This may be a time register worked by the clock in the signal cabin. The instrument on the engine may also be fitted with a similar register.

C. H. Siemens introduced considerable improvements in the

"step by step" electrical instruments and in the telegraphic "block" system of working.

The inventors of 1873 seem also to have given special attention to the application of electro-magnetism for the direct working of signals and points.

W. H. Preece proposed to work semaphore instruments with one line wire, and to render them less liable to lightning contact.

A. M. Clark, in February, brought out an elaborate arrangement for working the "block" system and single lines, so that *absolute reliance* can be placed on signals which are in perfect connection with the electric apparatus, which is actuated by the working of the signals in such a manner that the apparatus would indicate both when a train enters upon and quits any section of the line, in addition, in the case of single lines, to showing whether the line is clear or blocked by a train travelling in the opposite or the same direction. W. Bradley invented an appliance for locking signals and points outside the cabin, so that a shunter could control the points. The locking appliance is attached and connected with the points close to or opposite their junction with the rails; the ends of the signal lever-rods pass into the bars of the shunting levers through apertures made for their reception.

In July, Ernesto Spagnoletti introduced improvements in combining electricity with the actual signals used along a line of railway. Two or more electro-magnets are so placed as to form pairs. Two pairs of the electro-magnets are placed opposite each other. On a rocking shaft is fixed a sheet of soft iron so arranged as to be under the influence of the electro-magnets, whichever set may be brought into action. On the rocking shaft a toothed wheel is placed, or part of a wheel, so arranged as to multiply the arc given by the rocking shaft. This toothed wheel works into another one which is attached to the semaphore or glasses, or whatever form may be required to be worked. The electro-magnets which give the moving power to the signal are charged by a galvanic battery, connection with which is made either by a person making contact by small levers so arranged with a slotted sliding bar that only one can

be worked at a time, and when worked be put back before the sliding bar can be moved to work another handle, and the putting back of the lever or handle affects the signal. This system can be applied to ordinary signals and points.

A second or third sliding rail, if required, can be used; or by means of a treadle or spring so fixed on a line of railway that the passing of a train can make contact, and thus this system is self-acting.

The electro-magnets can be worked with direct currents, or by preference by a local battery by the use of a relay.

If this be used, the relay is arranged so that as soon as it is brought into use the bolt-lock is withdrawn, the required contacts are made, and the local battery is brought into action, and these contacts are kept on until the signal in going up or coming down breaks the contact. These means secure lengthened contact for the local battery as may be required. Attached to this apparatus, and working also with the action of the electro-magnets, locks are so placed that upon a signal being put up or taken down it remains locked in that position, and it can only be removed or altered by the action of the opposite magnets, which are required to be used to alter the signal. This system can be applied to semaphore posts, and works the rod attached to the arm. The ordinary slotted spring treadle, or centre hinged treadle, or a tipping treadle, or a multiplying lever acted on by the deflection of the rail may be employed. The centre hinged treadle is made as follows: two long pieces of iron hinged at each end attached to the balk, sleeper, or other foundation, the two loose ends coming within a foot or eighteen inches of each other; this space is filled up with a short piece of iron, flat, on hinges at each end, so that it obtains movement at each end of the long rods it is attached to. Under this centre-piece is placed a strong spring or lever with a weight attached at the other end of sufficient weight to keep the treadle up to the level of the crown of the rail, so that the flange of the wheel depresses the treadle, and contact is made by the rod or lever being brought into position by the cocking up of the same at the opposite end to that depressed, it being fixed on a centre.

The tipping treadle is made thus: a long rod of square iron is journalled at certain intervals for bearings. On this rod are fixed a number of T pieces. These are shut on to the rod or bar so as to form a continuous piece of metal on which the flange of the wheels of a train can run, or instead of using T pieces, another rod or an iron plate can be fixed on to the rod or bar.

Under the T pieces or the plate are put at certain intervals certain spiral or other springs, or a lever rod or rods with counterbalance weights, as before described, and an electrical contact maker is attached, and electrical contacts are made by the action of the treadle to take down the signal at the station in the rear, to put up one at the station or point required when passing, and to ring a bell to the station in advance. Three contacts are therefore required to be made, which is done by the action of the treadle, and more can be made if required (if treadles are used), or the deflection of the rail by the weight of the engine can be used to work a piston with a multiplying bar or lever, and a treadle may thus be dispensed with; or signals can be made by the signalman, if signals are required to be worked by men instead of treadles, when there must be a row of small levers with a slide rail in front of the levers with a slot in it, so that only one lever can be pulled down, and that one the one opposite to the slot, and the sliding bar cannot be moved for any other lever to be pulled down till the lever which has been pulled down is first put back. This locking system may be applied to ordinary signal and point levers.

At junctions where two, three, or more lines run into one, a system of locking signals is arranged by having an apparatus made so that by putting in a piece of metal with a handle to it, it can be slid backwards and forwards in a groove or channel, and by this action it is so contrived that when it is slid forward the signals are put to "all-right," and when backwards, to danger, or *vice versâ*.

Over this groove apparatus there is a sliding box, with an aperture in it, so that all the holes into which the piece of metal is put, with the exception of one, are covered up, and only one signal can be got at at a time, so that the signals are locked, and

only one signal can be worked at a time, and no two signals can be taken down together. The signals are so placed that even then they cannot be worked unless the points are in the proper or required position for a coming train, or the point lever can be made to put the signal up to danger.

In signal boxes there is attached to the ordinary locking frame "Spagnoletti's" electric tell-tale clock, by which means a register can be kept of the time a signal is in any position, up or down, during the day or night, and how long it is in either position. These tell-tale clocks can be placed at each signal, and worked by the movement of the actual arm. On the signal rod or rocking shaft, worked by the magnets, an apparatus for electrical connections is fixed, to which a signal repeater is fitted in any required place, so that when treadles are used at intermediate boxes, where no signalmen are kept, the repeater may show the men on either or each side the condition of the signal at this intermediate place, and thus the working of the signal can always be seen at the passing of every train by the men, and its working checked.

In the signal lamps a light repeater or tell-tale is placed to advise the signalmen if the lamp is in or out, so that the most perfect arrangement may be thus secured.

This light repeater is formed of a tube of glass bent like a U, with the bulb at the top containing quicksilver, or quicksilver and spirit. At the ends a terminal screw is fixed, with a small piece of metal running into the tube, so that when the lamp is alight the quicksilver expands by heat, and touches the piece of metal, and makes electrical contact, and shows an indication on an instrument in the signalman's box, "lamp in," and when the lamp goes out the quicksilver falls by contraction and severs itself from the piece of metal, and the severance, by breaking contact, signals to the man in the signal box, "lamp out." If quicksilver and spirits combined are used the result is just reversed, the quicksilver making contact when the lamp is burning badly or out. For calling the attention of drivers of engines to the signals, or to ordinary signals, there is placed on the engine a bell and battery, and also a spring. On the line of railway between the rails is fixed a piece of metal, so

that the engine spring, passing over it, comes into contact v the piece of metal, and this secures electric connection, and r the bell on the engine until the driver stops it. These pi of metal can be placed and arranged at any convenient dist from a signal, so that the driver may have his attention ca to the fact that he is within a certain distance of a sig and thus in thick or bad weather the chance of his passin unobserved is overcome. This bell may, if preferred, b arranged that it will only ring when the signal is at dan This can be mechanically arranged only, if thought desira so that the whistle of the engine can be blown to give similar notice.

FIG. 91.

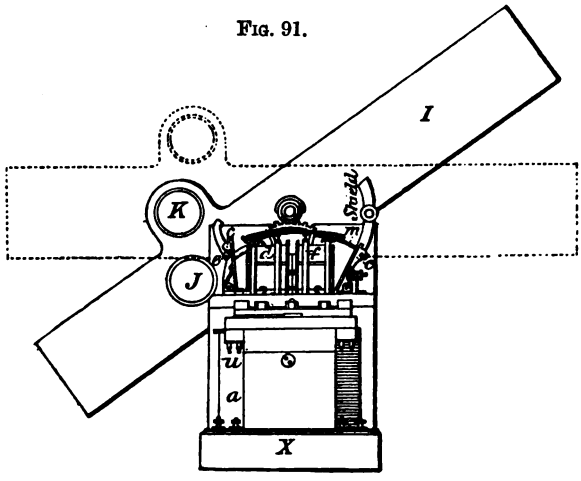


Fig. 91 illustrates a back view of the signal; Fig. 91*a*, fr view. In these drawings, *a*, *a*, are the electro-magnets, wor by local battery; *b* armature or plate of iron, acted on by *a* *c*, *c*, locks, locking signal arm up and down; *d*, *d*, relay acting on *c*, *c*, which when withdrawn releases *e*; *e*, *e*, the b pins on the arm; *f*, *f*, relay detents, which are knocked off motion of arm moving up or down; G, toothed quadr worked by arm attached to *b*; H, pinion on which arm I wor *j* and *k*, glasses for night signals; *l*, *l*, contact points for wc ing signal repeater, showing signal "on," or signal "o

m, m, a second relay, released by the blow from *c*, and putting on to coil; *d, d*, the local battery temporarily, which works *a, a*; X, case.

FIG. 91*a*.

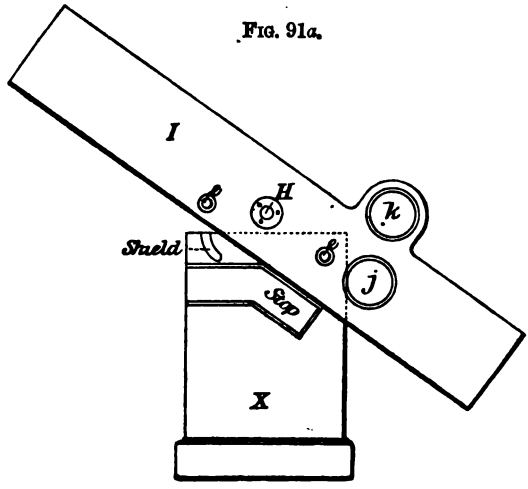


Fig. 92 shows a semaphore signal, with the apparatus of Figs. 91 and 91*a* adapted to the working of this signal by acting on the rod attached to the arm instead of direct. I, signal arm; G, quadrant; N, locking pins of quadrant, instead of *c* in arms.

Fig. 93 represents a tell-tale or repeater worked by the signal. The top half shows whether the lamp is "in" or "out." The bottom half the position of the signal. A bell may be added if required.

Fig. 94 shows a tip treadle on plan. Fig. 95 transverse elevation, and Fig. 96 longitudinal elevation. *a, a*, bar of iron; *b*, journals; *c*, contact maker; *d, d*, pieces of iron T-shaped shoes; *e, e*, railway metal. The passing of a train over *d, d*, trips it up, and makes contact at *c*, rocking on the journals *b*; *f* is a spring restoring shoes *d* to normal position.

Fig. 97 shows the alarum to driver, to give notice to him of his approaching a signal. *a* is an electrical bell; *b*, battery; *c*, wire; *d*, flexible spring; *e*, rail; *f*, piece of bent metal with earth connections, so that on an engine passing either way

the spring comes in contact with the earth, and electrical contact is made, which sets the bell ringing, which has to be stopped by the driver. Notice of his approach to a signal is thus given.

Fig. 92.

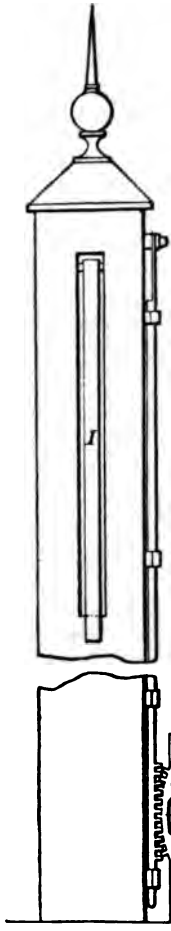
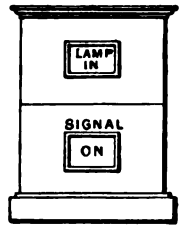
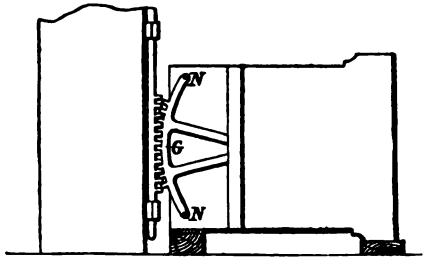


Fig. 93.





Figs. 98 and 99 represent locking apparatus for contact makers. *a*, levers; *b*, locks; *c*, ratchet; *d*, frame; *e*, stop spring or handle; *f*, stops; G, spring; H, contact spring; *i*, *i*, contact spring also, so that on the movement of the lever either side of H and *i* are brought into contact, and G is severed from H, and the required current is transmitted to work the signal; K, shifting bar for locking handles.

By this no two handles can be moved at the same time, and the one used must be put back before the bar can be slid or moved for another to be worked.

Without doubt all the inventors aimed at ensuring certainty and security of action in their various machines, and hence safety to traffic; but a very small number of those really available have been brought into actual use; a few are positively absurd; many are beyond the possibility of general application; and some, though ingenious, are much too complicated and expensive, while others have been tried and failed in reliability.

The systems of signals and locking apparatus most extensively in use are those of Whitworth, Stevens, Brady, Saxby and

FIG. 94.

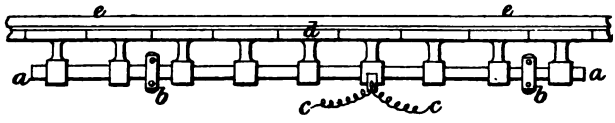


FIG. 95.

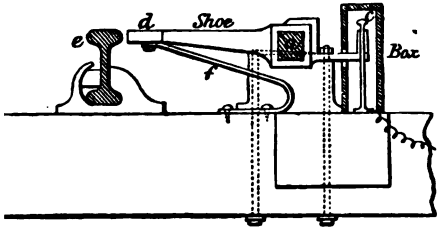


FIG. 97.

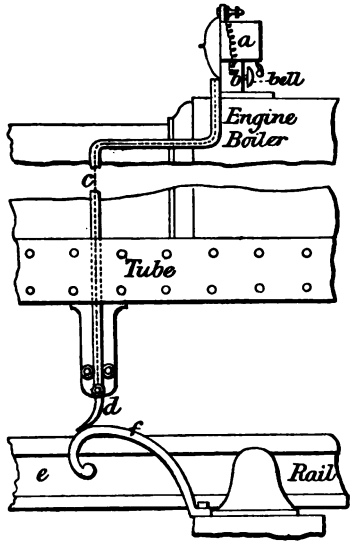


FIG. 96.

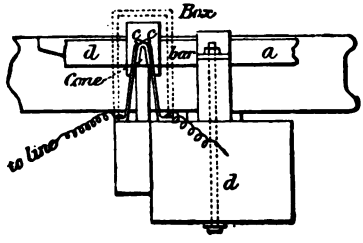
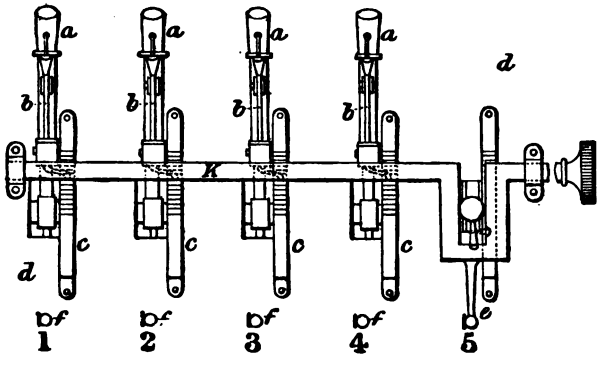
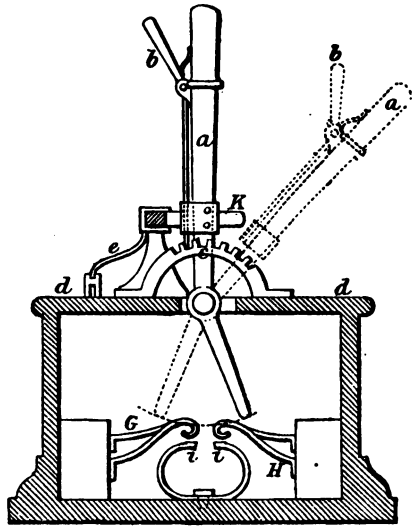


FIG. 98.



Farmer, McKenzie, and Anderson, with those of several private inventors scarcely known beyond their own locality; and the electrical apparatus of Messrs. Walker, Tyer and Norman, Preece, and Spagnoletti. One of the most completely worked out and perfect arrangements is that at the Cannon Street Station, where there are 72 point and signal levers, besides the more recent additions of engine discs, arms, and lamps, but which latter at the time of the author's visit did not interlock with the general system, thus leaving it perfectly open for a collision to occur at any time between an engine and train should the operator's memory fail him for a single moment. The plan adopted at the Victoria Station, as previously explained, is the most serviceable, as it combines indicating discs with the semaphore arms; but either of these stations, or many of the principal railway termini and junctions, would afford sufficient and interesting detail for separate pamphlets.

FIG. 99.



PART III.

HAVING traced the development of signals down to the present time, and seen what systems and means have been offered for application, it will now be needful to consider in the third place the practical results arising from those adopted, judging from the nature of the accidents and misadventures occurring either through the absence of signals, their insufficiency, or defective mechanical working.

The main object of railway directors and their engineers and contractors was in most instances to push forward the works so as to have the permanent way laid, and just sufficiently consolidated for traffic to ensure the inspecting officers advising that their lines might be opened, but in the general scramble signals were frequently last thought of; in some cases lines were opened without any reference being made as to their disposition; but soon after the first rush was over, the Inspectors of the Board of Trade saw the necessity of their taking special cognizance of signal requirements, and then openings were frequently deferred for one, and sometimes two months, until they were provided, at least at principal stations and junctions.

In 1840 the Board of Trade recommended that there should be fixed signals and a revolving lamp at every station; yet year by year complaints were made of companies disregarding these suggestions, for Sir F. Smith reported in 1841 that there were no standard signals at several stations on the South-Western, Sheffield and Manchester, and other lines, and that many accidents were directly traceable to their absence. Colonel Pasley, in 1844–5, similarly complains in numerous instances, and the flags so much in use were entirely condemned, as having frequently either misled the drivers, or not being distinguishable on account of the wind blowing them in the same direction as the train. A case of neglect on the Ulster Railway is worth citing. Inquiries were made in 1841 as to the erection of signals, and in

1848 Captain Simmonds reported that this company had not then any in use, but upon his urgent advice semaphores were eventually put up.

About 1848 the inspecting officers found it positively necessary to insist, so far as power was given them, upon signals being more generally and systematically erected, and in such a manner as they from time to time saw fit to suggest, before a line was opened; but they continued to report that the fact of signals not being provided was constantly their reason for advising the Commissioners to withhold their consent to the opening of various lines; and in 1849 alone, a dozen instances of this kind are recorded; the officers were constantly met with objections; and even direct refusals to comply with their requests were made by various companies; among many such cases is that in connection with the Hastings and St. Leonards Extension in 1851, which was to be worked by two companies; the signals were found incomplete on inspection, and no working arrangements had been made, the Commissioners therefore declined to give their consent to the opening until a careful code was agreed on; considerable difficulty arose in consequence between the contending companies, resulting in the South-Eastern blocking up the Brighton Company's junction; and not until then was an understanding come to which complied with the views of the Board of Trade.

The Warrington, Arpley line was first inspected in March, 1855, and its opening refused on the ground that the signals were not sufficient for the safe working by three companies. A desultory correspondence extended down to the 28th of November before a final settlement was made, and even that was far from satisfying the minds of the officers of the Board of Trade. One company objected because its system of signals was to be altered at the junction by a new one coming on its ground; another, because they were called on to pay the cost; and the third objected to take any share of the responsibility of the suggested method of working. How many chances of accident arose from such a state of things is not known; but one did occur in 1862, when Captain Tyler re-recommended what he did in 1855, but nothing was done by the companies, nor any

explanation offered by them, until, in 1867, a more serious accident took place, in which 8 persons were killed and 70 injured. Colonel Yolland severely commented upon the neglect of the railway officials, and stated that the efforts of the inspecting officers were strenuously opposed and successfully resisted by important railway companies objecting to comply with their requirements, and that the Board of Trade had no control whatever over railways after they were once opened, however defective or dangerous the arrangements might be. The disaster alluded to had the salutary effect of convincing the company of the necessity for the improvements so often suggested.

Through an accident at Holmes Junction, on the Midland, in 1856, the inspecting officer advised the remodelling of the junction signals, by having a double-armed semaphore at the junction point. The secretary of that company was instructed to reply to the Board of Trade, and state that the practice on their line was the result of the experience of men whose lives had been spent on railways, and that it was their unanimous opinion that the public safety was well cared for. However, an accident occurred at the Swinton Junction in 1860 from the same cause, and the driver of one of the trains confirmed by his experience the necessity of the officer's recommendation.

In June, 1866, the same company formally protested against being compelled to adopt certain so-called improvements in locking points and signals prior to sanction being given to the opening of a line. They further remarked—"They were acting in direct opposition to their own convictions, and they must decline, so far as lay in their power, the responsibility of the locking system."

It must not, however, be inferred that all the railway companies were equally antagonistic in this respect, for conspicuous among the exceptions stands the Great Western, who submitted to the Board of Trade, in 1841, a complete code of fixed and other signals, illustrated by diagrams; and the South-Eastern, who to some extent emulated that company. A prolific source of mishap has always arisen from the absence of signals, their defectiveness, and even from their being disregarded by engine drivers.

During the latter five months of 1840, out of 28 accidents 21 were attributable to the above causes, and each of the succeeding thirty years shows an increase in these numbers beyond the fair proportion due to the rapid augmentation of traffic, although, happily, the loss of life and injury to passengers has not followed in the same ratio. Two hundred and eighteen of the train accidents which have occurred in the past three years are thus divided:—

1870.	From defective signals and apparatus,		46;	at facing points,	14
1871.	"	"	"	41	"	12
1872.	"	"	"	71	"	34

in which year three companies alone contributed 24 cases of defective signal or point arrangements,'10 being on the London and North-Western, 9 on the Lancashire and Yorkshire, and 5 on the North-Eastern Railway.

From among the official records of a long list of accidents, as just classified, the following at other places than junctions are selected as being the most important.

A collision occurred at Nine Elms in October, 1840, when 1 passenger was killed and 70 injured. In 1845, at Defford, and at the Campbell crossing on the London and Birmingham line, where it was customary to use flags and hand lamps only; and also at Brandling, and on the Preston and Wyre line. An accident took place at Penshurst under peculiar circumstances; a train was dispatched without tail lamps, and in case they might be required, a pilot engine was sent on with them, and ran into the very train for which it was conveying them.

In consequence of a collision in 1848 on the Lancaster and Preston line, Captain Laffan reported that he had the flag signal hoisted, and found that at 200 yards distance it was not distinguishable, as the wind blew it round the mast; pieces of stick were frequently fixed, so as to keep the flag stretched open, but a varying wind soon caused them to fall out; one flag served for both up and down roads.

Captain Codrington had complained of such an arrangement on a previous occasion, and this second remonstrance had the effect of inducing the company to erect fixed signals.

In 1850 an accident, injuring 16 passengers, resulted from the want of auxiliary signals, near Stratford, on the Great Eastern, and the inspecting officer recommended the use of such signals at a distance of 600 yards beyond a station, so that a train might draw up within it, and so protect itself. At a collision at the Hogside colliery it was proved that, although there were north and south signals, the former was seldom lighted, for economical reasons, and a man was sent back instead to signal any following train by a hand lamp.

Collisions occurred in 1851, in the Sutton tunnel, Cheshire; two trains were delayed through a mishap to one of them, and a third train ran into them; also at Kirkstead, New Cross, and Kirtlebridge; each entailing considerable injury to passengers.

In the following year 26 persons were injured at Bootle Lane, and other accidents took place at Perth tunnel; also at Newark level crossing, where the signals were kept at danger, the understanding being that the train first nearest the crossing should have precedence, consequently a race frequently arose between two trains to obtain this, resulting in the present instance in a serious collision. Captain Wynne suggested that one line should be normally blocked and one open, but the Great Northern and Midland Companies could not agree, and eventually it was decided to maintain the old system, giving precedence always to Midland trains.

During 1853 accidents at Braidwood, Slateford, Newton Heath, and Weldon tunnel, may be instanced. A branch line of the North Union Railway was worked in 1854 by six different colliery owners, who ran 120 trains in the twenty-four hours, as best they could, without any kind of time, code, or signals; and it was reported that at St. Helens a boy fourteen years of age was employed to attend the points; at Walsall a woman in one instance and a girl of thirteen in another, was deputed to give the signals; also that flag signals were still in use at Hombridge, Forge Lane, and Rye-croft, on the South Stafford line.

At an inquiry as to an accident at Abergele, in 1858, it was given in evidence that there were no distant signals; and

25 passengers were injured at Mollington in consequence of a lad of fourteen being left by the signalman to work the signals. Among collisions during 1859 were those at Abernethy, Taplow, and Fleetpond, arising from want of distant signals. At Mill Hill, Yorkshire, in 1861, 23 persons were injured. The North British line was reported to be the only one in the kingdom which adopted distant signals, and *no* station or home signals; and 27 passengers received injury at London Bridge through the signal responsibility being divided between the servants of two railway companies.

The Caledonian Railway, in 1863, only used fixed signals at some of their crossings and branches for obstructions, and hand signals for passing trains.

In a collision at Springwell, in 1864, 34 passengers were injured; and similar accidents occurred at Bamber Bridge, Pangbourne, and Congleton, where it appeared that the North Stafford Company kept their signals at danger, but the North-Western partially at danger and partially all right.

In 1865 an express train ran into one standing at the Weston Junction, injuring 20 passengers; 20 also were similarly hurt at Waverton, 11 killed and 30 injured at Rednal, and 10 killed and 40 injured at Staplehurst Viaduct.

At Salford Junction 15 persons were hurt, and at the inquiry it appeared that the distant signal at Victoria Station, erected a month previously, had not been used; it had constantly stood at danger, and so had been entirely disregarded; the intermediate signal was from its peculiarity quite useless; at the time of the accident all the signals were at danger, and green flags were used for regulating the traffic.

In 1867, 75 passengers were injured in a collision at Fullwood; and during 1868, 15 received injury at Sandy; 18 at Newsham Junction in the first accident, and 1 in the second accident about a month after, both arising from the same defect. Collisions occurred in 1869 at Shadwell, Gretna-green, Lockwood, Winsford, and Garston Dock, where 15 passengers were hurt, and at Niddrie, injuring 20. Penrith was the scene of a lamentable collision in 1870, in which 113 passengers were injured; it appears that three excursions were making their return journeys

in quick succession; there was no proper means of protecting them, and the telegraph signalling had from some cause become unreliable. Seven passengers were killed and 41 hurt near Harrow, principally through the absence of a distant signal at Wembly; there were also similar accidents at Rochdale, injuring 21; at Coventry, injuring 12; and at St. Nicholas, near Carlisle, where 5 passengers were killed and 30 injured. An instance occurred in 1871 of a distant signal having been erected at Stratford Junction, Salop, and not used for several years. A collision took place at Wigan in which 16 passengers received injury, one of the direct causes being the non-use of the distant signal. Twelve were hurt near to Bishopsgate Station, as, in consequence of the intended early transfer of the terminus to Broad Street, the company did not think it advisable to remodel the signalling arrangements; and at Wilsontown 1 driver was killed and 2 men injured; both engines were thrown off the rails, one of them on to the bank, as well as 21 wagons, 6 of which were completely broken up.

In a collision at Kirtlebridge in 1872, 11 persons were killed and 15 injured; had the points and signals been more efficient and interlocked, the accident could scarcely have happened—at all events the station-master could not have committed the mistake which he did. Sixteen passengers were similarly hurt at Berry Brow, 29 near Paisley, 4 were killed and 12 injured at the Agecroft sidings, and 20 injured near Kew.

It is to be feared that the Board of Trade Reports for 1873 will be lamentably numerous, judging from the great loss of life, which during the latter six months reached the unprecedented number of 48 killed and 854 injured.

A large number of collisions belong to the class now under consideration, but it may be undesirable to detail them in the absence of the official summaries.

The imperfect and careless protection of junctions was as prevalent as that of stations and tunnels. The system of using one semaphore arm at the point of junction for two lines, although there were frequently, but not always, separate signals up and down in each direction, was constantly being condemned as a fruitful source of accident.

In 1854 a collision occurred at Knighton through the lowering of the junction signal being taken by two trains approaching together; a similar one took place at Hitchin Junction in June 1859, injuring 35 persons, when it appears that there was only one main signal, and the man in charge exhibited a great deal of hesitancy as to which train should be first admitted; one (the Midland) was pulled up at the distant signal, the main being at danger; the latter was then lowered to caution, and the train proceeded to the junction, when it was again stopped, and backed; several conflicting signals were afterwards given, which resulted in the Great Northern and Midland trains coming into collision, through mistaking for which the *last* signal was intended. It was reported in June, 1860, that out of 67 junctions on the Midland line, 46 had single semaphores only. Collisions occurred at Water Lane in 1863, and again in 1864, in both of which instances the inspecting officers advised an improvement, remarking that it was a defect peculiar to the Midland, which had from time to time for many years been brought under the notice of that company. In 1868, 67 passengers were injured at Wellington through the signals being mistaken by two trains running into the junction simultaneously.

Colonel Yolland stated, with reference to a collision at Heaton Norris Junction, in 1869, "I consider the mode in which the traffic is conducted is very objectionable and dangerous, but the Board of Trade have no authority to interfere." In 1871, 30 persons were injured near Reading from want of efficient signal and point arrangements; a similar accident occurred at Norwood Junction, injuring 16 passengers; and at Red Barns, on the North-Eastern, whereby 26 were injured. During 1872, collisions took place at Willesden, injuring 38 passengers; at Redhill and Newport, where 1 passenger was killed and 14 hurt; besides 8 minor instances.

It is surprising that on what are deemed well-appointed lines, where proper protection is supposed to be provided in the form of distant, repeating, and station signals, combined with telegraphy, or the more elaborate arrangements for working the "permissive block," or "absolute block" systems, there should exist at times such a laxity of working the whole as to destroy

that confidence which engine drivers should be able to place in the signalman's care, the contradictions so frequently existing have caused the signals themselves to become utterly disregarded, for although distant signals were found to be essentially necessary, from well-bought experience at the cost of many lives, it might almost be said that they have been established more to comply with recommendations constantly urged, than with any intention of regarding them in the proper light. Instances of this kind are painfully numerous and aggravating. A collision occurred at Leicester in 1850, through the driver disobeying the distant signal; it came out in evidence that in consequence of the frequency with which the danger signal was against an approaching train without apparent reason, it was habitually passed at a reduced speed, and had been so for eighteen months with the full knowledge of the Company's officials. In the course of examination into a collision at Wednesbury in 1853, it was proved that the engine driver constantly passed the danger distant signal, and that the drivers of the passenger trains were more reckless than those of the goods. At Rutley, in Devon, an understanding existed between the drivers and signalmen, that the former were not to wait for the danger signal being turned off, as the latter had to run a long distance to the lever. At Hatfield, in 1856, it was found that drivers were in the habit of passing caution signals at speeds of 35 miles per hour. Twelve passengers were killed and 62 injured at Lewisham, on a Sunday, in 1857, in consequence of the distant signal being passed at danger, the drivers having so frequently learned that the "line clear" was given by wire, and the signal left at its normal position, that they did not respect it.

At Sowerby, in 1863, a new distant signal was erected and recognized for about a week, but the drivers finding that it was always in accord with the station signal disregarded it, and soon after as a natural result an accident took place, injuring 14 passengers; and at Wolverhampton similar neglect caused injury to 39 passengers.

On the North-Western line at Sudbury, in 1865, a collision occurred: it was proved that although there were forty-two tele-

graph stations between London and Rugby, the distant signals when at danger were often passed at speeds of 20 miles per hour, and that it was endeavoured to establish two kinds of danger telegraph signals, one "train on line," and the other "danger," but it is impossible to determine what practical difference can exist between the two.

In the following year at New Cross 50 passengers were injured from the same cause: both distant and station signals were at danger, and hand signals and flags were used for admitting the trains. One of the clauses in the regulation book for the Vale of Neath line, which came under special notice in October, 1865, states that "distant signals must not be relied upon to protect any train between them and the main station signals." In 1866, 12 passengers were hurt at Hitchin; 35 at Huddersfield and 45 at Derby in 1867; 45 at Stockport and 12 at Ashton in 1868; and at New Cross in 1869, 1 person was killed and 357 more or less injured, all from a direct neglect of signals. In 1872, five carriages were thrown off the rails at Stoney Street, on the Charing Cross line, and 17 passengers injured, owing to the driver not stopping his train at the distant signal; and similar accidents occurred at Dalton; at Chepstow, injuring 21 passengers; at Bury tunnel, Middleton Junction, and Carmarthen; also at Guide Bridge in 1873, when 1 passenger was killed and 37 others injured. Captain Tyler observes, in his report upon this accident, that "no excuse can be made for the Midland engine driver." These cases are irrespective of a considerable number of lesser magnitude, but each of which occasioned some personal injury or death.

From close observation it is very evident that the recklessness of drivers may be traced back as arising from the irregularity with which distant signals were worked by the signalmen; where the cabin was in sight it became a rule to motion on a train past the signal at danger by flags or by hand rather than take the trouble to release it before a train was sighted and put it on again after its passage; then drivers lost faith in a danger signal, and they, so soon as they came in sight of it, began to "whistle it down," and ultimately to disregard it *altog*ether. At the inquiries into most of the accidents of this

class, it was proved that danger signals were habitually passed at all speeds, from 12 to 30 miles per hour, and the inspectors' complaints of such recklessness were in no way too severe or numerous.

Under a miscellaneous head the following accidents are noteworthy. In 1847 a driver of the Brighton Company ran through the Merstham Station in defiance of the South-Eastern red light; the former company apprehended the driver, but when he was brought before the magistrates he was discharged in consequence of there being no form of prosecution prepared. Fifteen passengers were killed and 5 injured in a collision at Straffan in 1853, through the absence of tail lamps. At Hackney, in 1858, a collision occurred whereby 44 passengers were injured through the failure of a self-acting treadle signal; the train on passing it pressed down a lever, causing the arm to rise to danger, and a bell to ring at the station; but if the train passed the signal at danger no bell would ring; it was found that unless the weighting was frequently adjusted the arm was not certain to rise.

One of Whitworth's treadle signals failed at Radcliffe Bridge Station in 1859, and another near the Clayton tunnel in 1861, when 23 passengers were killed and 176 injured. No record books were kept; there was only one wire needle for working the line, and the two trains which came into collision were started within seven minutes of each other. At Stepney a self-acting signal failed, and was the cause of an accident; the train actuated the semaphore arm to rise to danger by the usual lever; it was not constructed to return to all right; the signalman at the station had to release it after the passage of the train, but he had no power to set it to danger, and if he wished to do so he must walk down to it or depute some one to do so. Twenty-six passengers received injury through "fly shunting" on an incline at Bishops Auckland in 1869; this dangerous proceeding it will be remembered was the immediate cause of the fearful calamity at Abergele in the previous year.

At Carlisle, in 1870, 26 persons were hurt by an accident attributed to the disregard of a printed regulation, and which had been disobeyed for upwards of five years.

A number of accidents may be traced to the slackening or breaking of the signal wires. In such a case the arms were not, as a rule, arranged to fly to danger. The expediency of their so doing was a point of contention. The Board of Trade Inspectors desired that they should do so, but some of the railway authorities did not consider it the most suitable method of ensuring safety. Frequently, also, signals have only partially exhibited themselves, in consequence of no provision being made for counteracting the expansion or contraction of the wires; and instances are to be met with almost every day of an intended danger signal being several degrees below the horizontal, or a spectacle lever signal being half balanced.

At Lesmahagow, in 1869, it appeared that the down distant signal of that station and the up distant signal of Motherwell Station were on the same post. One of the lamps went out, and the back light of the other was mistaken by the driver for the proper light, and a collision was the consequence.

At Dunning, in 1871, a distant signal arm did not fully rise to danger, occasioning a collision, in which 13 persons were injured and 1 killed; and at Monkwearmouth the same defect caused injury to 21 passengers. Among similar accidents which occurred in 1872, three may be noted: one at Quay Junction, on the Llanberis and Bangor line, and others at the Milsom Station and Motherwell Junction.

In 1873, 42 passengers were injured in a double collision near Bolton. Numerous defects combined to bring about this disaster. The signals and appliances were in a very indifferent condition. The cabins were said to be twenty years old, which their dilapidated state evidently confirmed; and a rule regulating the dispatch of trains had been utterly disregarded for about eight years.

The failure of self-acting switches, in some cases even of locking apparatus; the opening of points for a line contrary to that for which a signal had been lowered; the shifting of points away from the stock rail by a passing train, and the employment of unlocked facing points, as defects within remedy by mechanical contrivance. The practice of altering signals and *points before* a train has wholly cleared the several parts in

direct connection with the actuating mechanism; the employment of whistle, gong, and hand indicators, to save time and trouble in working fixed signals; and, above all, the continued disregard paid to the rules for working the traffic, either by "intervals of space," the "permissive block," or "absolute block" systems—and that with the knowledge of the officials, who should insist upon a rigid observation of the codes as matters of neglect, capable of amendment and absolute avoidance—have each been a prolific source of injury and damage.

A few instances as illustrations will suffice. At Wolverton, in 1847, a train was inadvertently run into a siding, killing 7 persons. At Gloucester, on three occasions, the inspecting officers had to request an alteration of the same switches; 6 passengers were killed and 20 injured at that station in September, 1851, by a signalman moving the points while the train was passing over them, in consequence of his discovering that he had opened the wrong road. At Clayton, where a switch lever had been chained and fastened with a padlock, the bar was withdrawn, and passed over outside the chain by the switchman: this mode of procedure subsequently caused a collision.

In 1852, 72 persons were injured at Reigate through the points and signals being at variance; 42 were hurt at Deptford by self-acting switches failing; at Nine Elms, in 1865, the facing points were worked by one man and the protecting signals by another from a different cabin; this state of things ultimately caused injury to 41 passengers. In 1866, at Charing Cross a set of levers were so defective that a signal could be lowered before the points were fairly over, which were not even locked when the semaphore arm was wholly down; this occasioned a collision, and 22 passengers sustained injury. On the North British line, at Trinity Junction, in 1868, it was found that a signal could be lowered when the points were open half an inch, and they sprang full open while a train was passing over; a collision occurred at Chester in March, 1868, by the points and signals being contrary; and again in September, by the same man and with the same points.

At Cannon Street, in 1869, a boy moved a pair of points while a train was passing over; and in 1870, at Tamworth, 3 passengers

were killed and 10 injured through the facing points being open for a siding when the main line signal was all right. A signalman at Kensington, in 1871, moved a pair of facing points before a train had wholly passed over them, and caused the train to be split into two. Sixteen passengers received injury at Accrington, 16 at Nottingham, and 1 killed and 10 injured at Unston, in consequence of facing points being wrongly set. Similar accidents occurred during 1872; on the South-Eastern by a signalman shifting the facing points while the train was passing over, and 61 passengers were more or less hurt. The same kind of mistake split a train at Charing Cross. At Willesden it appeared that the signalman raised a starting signal to danger before the train had passed the points, thus unlocking the point lever; and 13 passengers received injury at the West Worley Junction by the opening of the points during the passage of the train.

The sad occurrence at Wigan last year was undoubtedly due to the speed at which the train was running over the facing points; but against the verdict given by the jury who sat upon the inquests, which was formally "Accidental Death," and behind which the North-Western Company shelter themselves beyond any responsibility for the accident, it would be injudicious to make any assertions; at the same time it is allowed on all sides that to drive a train through a station like Wigan over facing points at from 40 to 50 miles an hour is one of the most reckless and wicked acts that any company could authorize or tacitly permit.

A disastrous accident took place at Hampstead in 1861, when 15 passengers were killed and 317 injured, in consequence of it not being customary to block the line while shunting was going on, unless the weather was unfavourable. At Market Harborough, in 1862, 142 passengers received injury in a collision between two excursions, which were allowed to follow each other within an interval of five minutes; and one of the causes of the Abergele catastrophe arose from the want of a proper interval or block system, aggravated by what is technically termed "fly shunting;" this latter system is practised to a considerable extent at all stations and sidings, and has alone been the cause of many accidents.

In 1868 the working of the block system on the North-Western admitted of more trains that one running between stations, provided the second train followed at a slow speed after an interval of three minutes.

Sixteen passengers received injury in a collision at the Portland Road Station in 1869, by the signalman giving "line clear" to admit a third train upon his length of road. A similar occurrence took place in 1871 near the King's Cross Station of the Metropolitan line, when it was proved that the block system which should have covered a distance of $\frac{5}{8}$ths of a mile was reduced in practice by the method of working to about 76 yards, and this at a point where 469 trains passed during the day. At Derby the block system was abandoned, as being considered by the railway officials impracticable and inconvenient; this resulted on a subsequent occasion in a collision which occurred during a fog, whereby 29 persons were injured.

An accident happened on the North London line at Shadwell, through the signalman being in the habit of dispatching the trains to the next station without receiving the "line clear" signal.

On the Lancashire and Yorkshire Railway trains were run at intervals of 60 and 70 to 300 yards, in direct opposition to the company's rules. The Board of Trade officers had occasion to denounce this as a "vicious system," and certainly not without just reason.

During 1871 the following casualties may be cited: a collision at Poplar through the signalman unlocking his signal by pulling off his communication disc before he received the "line clear" signal; 20 passengers were injured at Scott's sidings, near Moseley, although the line was worked under the "permissive system;" another similar accident occurred at the same place a few months after, when it was elicited in evidence that the signalman had a private system of signalling, but which was by some means differently interpreted.

A double collision took place at Barnsbury, where the "block system" was in force: a passenger train was allowed to follow a coal, and goods train; the passenger train ran into the coal train, the rear engine of which started forward in steam (the driver

had been thrown off, and the stoker jumped off), overtaking and running into the preceding goods train. In 1872 numerous collisions are reported; at the Valley Station, between the Irish mail and a goods train; at Houghton, between a passenger and goods train; and at Carter House Junction, injuring 17 passengers. Two passenger trains came into collision during a fog at Barnwood, near Cheltenham, whereby 25 persons were hurt; also between Smallwell and Rowlands Gill stations, from which 90 persons complained of injury, the two trains were started within five minutes of each other; and 22 persons were injured at Wormald Station.

The whole of the lastly enumerated accidents might have been completely avoided by a system of "absolute block" working, aided by strict discipline, both among those entrusted with the actual operation and the officers who have the supervision of the staff.

In selecting the cases under the foregoing classes care has been taken to give those only the source of which are beyond doubt; and it should be remarked that they do not form a tithe of the accidents which have actually occurred and might be classified; the object has been to prove assertions by positive facts, as officially reported, and therefore no surprise can be expressed upon reading Captain Tyler's report to the Board of Trade for 1871, wherein he remarks that "it is mainly because sufficient attention has not been paid in past years to the various means of safety so constantly recommended from the Board of Trade, that the great lines of England appear so unfavourably at the head of the accident list, the most wealthy, most powerful and important companies are just those which have too much neglected the application of such means, and frequently in those parts of their districts in which for the heaviest traffic they are most needed."

And again, in 1872, he writes, that "railway work is a description of work which must be *got through*. When it cannot be performed without risk, the risk is incurred. The officers and servants of the companies are too frequently induced, if not compelled, in the absence of necessary means, appliances, or accommodation, to disobey printed rules or to adopt hazardous

methods of working; and in the course of their daily work to become habituated to operations which they would themselves in the first instance see to be objectionable. They are often unduly blamed when accidents actually occur, because their difficulties in these respects are not sufficiently known or considered."

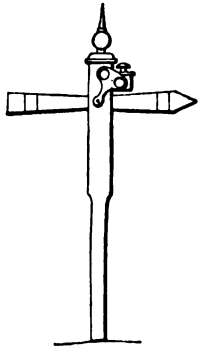
PART IV.

HAVING now reviewed some of the accidents clearly traceable to defective signals, their connections, and working, it will be necessary briefly to offer such practical deductions as may indicate, fourthly, what forms of signals and appliances and what systems of working the traffic thereby are most desirable to ensure a greater and more certain degree of safety.

Abundant evidence has been submitted, which may be accepted, to show that there are only two forms of signals which can be considered efficient, both as regards distinctness and simplicity, *viz.* that of the cross-bar and disc and the semaphore; variously formed discs should be entirely discarded, except for minor and specially-understood indicators, apart from the requirements for the main traffic.

With the conversion of the Broad Gauge into Narrow at some not far off date, the cross bar and disc and fantail signals will doubtless go out of use; the former is, however, capable of being seen at the greatest distance, but is utterly unsuitable for grouping.

FIG. 100.



The semaphore comes next, and as it combines the two essentials of clearness and adaptability to every requirement, it should be the system uniformly adopted throughout the English lines of railway; but it will be wise to urge the advisability of distinguishing between the semaphore arms for the up and down roads in all cases, whether in groups or singly on a mast, by some attachment, or better by a modification in outline. A tapered arm for the down road, Fig. 100, would not look unsightly, and yet be capable of receiving equally with the rectangular arm a mark, indicating, at difficult situations or where the groups are numerous, the particular train or road it governs, and thus

absolutely avoid any possibility of mistake, either from its colour or its numerical position. Such a form would, moreover, obviate the necessity of the "invariable rule," that the governing arm would be on the left side of the mast; for wherever and however seen, the down signal would be the tapered arm, and the up the rectagular, or *vice versâ* if preferable, so long as there was uniformity; and the arms might be coloured red and white as at present.

It does not seem advisable that any difference should be made in the form of the distant auxiliary or repeating signals, as is done on the Brighton and Midland lines, by rectangular and spectacle discs. It frequently happens that the distant discs of two stations are very near each other, and in some situations admit of being mistaken; whereas a form of semaphore arm, as suggested, would prevent the possibility of any such error, and enable them to be fixed on whichever side of the road or post might be found most desirable for sight, in deep cuttings, on a curve, and in other obstructed positions. Every station, crossing, junction, siding, and tunnel, should be protected by home and distant signals in both directions, sufficiently far apart to protect the longest train, the latter being fixed in such a position for view, determined in each instance by the nature of the road, either as up or down hill, on a level, on a curve, in a cutting, or on an embankment; so that under careful driving, the engineman of the fastest train might pull up by the time the signal was reached. Our engineers can calculate with sufficient accuracy for all distances, from the experiments which many of them have had occasion to make; and similar conditions should regulate the space between the distant and home signals, to provide for a train pulling up at the latter, after passing an "all right" distant at full speed.

It has become, after many recommendations, an established custom, and indeed forms one of the Board of Trade regulations for "new openings," to guard every road at junctions and stations by an independent distant signal, and by separate arms at the junction point for each tributary; but although recommended, no uniform method of reading the accumulated arms seems to be wholly adopted; sometimes they are counted

upwards and at others downwards where known by numbers, and in a few cases they are lettered, but the letters are not always distinguishable at a distance. It may be admitted that a driver in time gets thoroughly acquainted with his certain set of signals, provided he works one district; but still there is, as signals now exist, much room for mistake, and the most conversant of men are apt to be misled in consequence.

Small strips or shapes of sheet iron of thin gauge would answer all purposes of indication, and not materially increase the weight to be actuated by the balanced lever, and could be easily affixed to the semaphore arms, Fig. 101.

It should be insisted that the reading should always be from the top downwards, so that each road added its arm below that of its predecessor, taking the topmast for the main line.

Fig. 101.

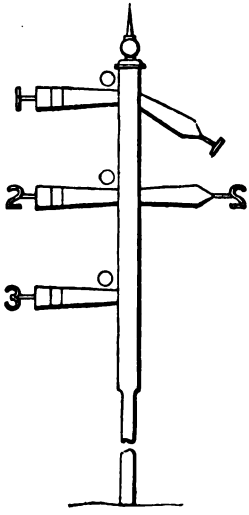
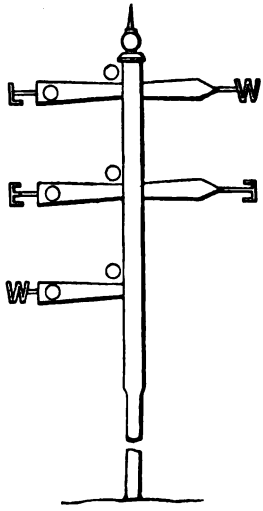


Fig. 102.

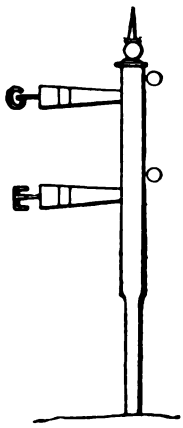


Where it is desirable to affix letters to the arms, they should not be merely placed on within the edges, but should show clearly as a projection beyond. Thus, the distant semaphore at the Surrey end of Cannon Street Bridge might with advantage be made more distinguishable, as shown in Fig. 102. This semaphore being exceptional in its double use for up roads in

opposite directions, there may be economy in having one mast, and making one set of lamps do duty for two sets of arms; but it is questionable if it is the most suitable plan.

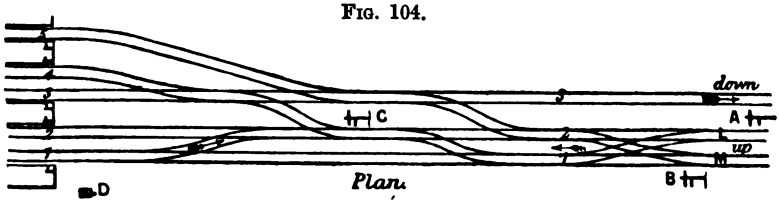
At stations where goods trains have independent roads, or where sidings are specially provided for that class of traffic, it is desirable that arms should be set apart for their separate use as admission or starting signals, and distinguished always by the letter G, as Fig. 103; similarly engine road signals might have the letter E affixed.

Fig. 103.



It would be advisable, moreover, to indicate to drivers the roads they are being turned into, in such a manner that each successive signal on being lowered, should exhibit a letter or figure, which at night would have a light reflected thereon, so that in every stage the drivers would see what signal next in advance is to be looked out for, thus completely avoiding a possibility of mistake. The indications should be sufficiently large and distinct to be seen at the necessary distance, which would not be so great as that at which it would be needful to see the semaphore arms. To suppose a simple case, say of two roads, "local" and "main," governed at the distant cabin A, Figs. 104, 105, by two arms M and L, giving access to three

Fig. 104.



roads, which in turn give access to five station or platform roads. Then, if two trains were approaching the cabin A, and two platforms were signalled from the cabin D as clear, the arms at A on being set to "all right" would indicate respectively the arms to be lowered at the mast B, the arms at which would

similarly indicate the figures to be seen at C, which latter admits immediately to the platforms; the mechanism for locking should be such, that unless the facing points at each of the masts were properly locked, the signals would not be lowered. On the two trains "main" and "local" sighting the signals A, the arms M and L would be seen down, Fig. 106, the former

FIG. 105

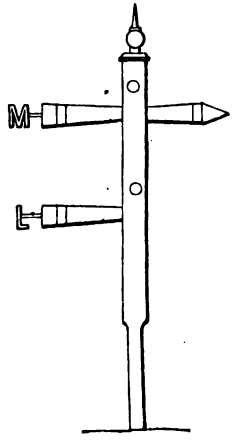
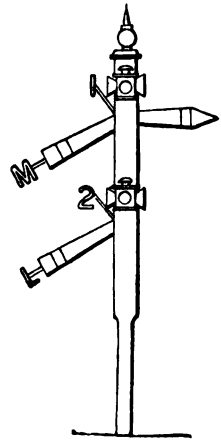


FIG. 106.



showing the figure 1, and the latter 2, being the semaphores next beyond at B; at these, arm 1 would show figure 3, indicating arm 3 at the next dividing points C, and arm 2 would show figure 5; should the corresponding arms at C be exhibited, the platforms would be clear. Of course all points fouling the two roads thus made up would be locked with their respective signals in the customary manner.

The starting signals are shown at the ends of the platforms close to the driver, and the necessary exit arms would be upon the masts C B and A.

All station platforms should have independent starting signals under the sole control of the signalman; in case of fog, at large stations especially, they would prove to be of infinite service, and at all times preferable to groups which are frequently fixed many yards distant from the platform ends, and *at a considerable* elevation.

In dense fogs it is a common occurrence for drivers to depend wholly upon verbal and hand signals for starting, which is really an indescribable combination of shouting and gesticulation; such a method of working cannot be too severely censured, and should be absolutely prohibited, except for yard shunting entirely away from the main line.

From circumstances constantly coming under notice, it seems that little discretion is exercised in determining the height of the signal masts, traffic managers have gone from one extreme to the other; formerly they were scarcely high enough to be clear of conflicting objects, now they are often nearly 40 feet high, without the slightest reason whatever, unless indeed it is to ensure the arms being out of sight in hazy or foggy weather. The simplest remedy for this is to place a repeating arm and lamp at such a height on the same mast, or in such a position on another mast, as to ensure the driver seeing it.

Signals actuated by passing trains are not at all reliable, and many companies who have fairly tested them have very properly given them up; consequently, if sole trust is to be placed in human agency for the working of signals, it should be protected by the best mechanical contrivances of our time, and assisted to the fullest possible extent by telegraphic signal communication, and that between every signalman and gatekeeper at level crossings along a line of railway, not a single exception should be permitted under any pretence.

Originally signal lamps were constructed without back lights, but practice showed that it was essential that signalmen should see that the lamp was burning; still as several accidents have arisen both from the want of the back lights and also from their being mistaken for the signal lights, some uniform alteration in the colours of the former is desirable; for where they face in the same direction as the signals, it is frequently difficult, both on account of colour and apparent magnitude, to distinguish the one from the other at a distance, but with a stronger reflector or more powerful lens a purple light might be used instead of green for the reverse of red, and where a white light is never used as a signal it might remain the back light for green; the present working of signals indicates that

as the "absolute block" system comes into use only two signal will be needful—danger, and all right; the white light for all right may be well discarded and green substituted; for as white, or what is termed a white, is the prevailing colour of artificial light, it would be safer to adopt other tints for signalling.

Numerous instances of accident caused by the loose working of the block systems have been given, but it is never known how many hair-breadth escapes daily occur; the simple telegraphing of the starting and arrival of a train by ordinary needle failed in its object, the "permissive block" as worked is no block at all; and daily experience tends to prove that the "absolute block" is little more than a name; the stages or lengths of road between two cabins are practically reduced so as to run the greatest possible risk of danger; signalmen send trains on with a caution in defiance of the telegraph instrument arm being up, they cease to work their signals truthfully with the telegraph, so that engine drivers become deceived and ultimately take little or no notice of danger or caution. It will not be an exaggeration to affirm that this is done daily, most carefully done, and the subordinate or intermediate officials wink at it. Where then is the remedy? The printed regulations of the various companies must be made less ambiguous and more rigidly enforced. It must be insisted that the state of the signals shall constantly agree with the telegraphic working; and if a driver passed a danger signal without positive and special instructions to do so, it should be at the peril of immediate suspension and a heavy fine; there must be no saving clauses, let it be distinctly understood by everyone employed on a railway that a danger signal shall not under any circumstances be disregarded, this carried out and the "absolute block" would become the only sure safeguard for a heavy and speedy traffic; the only reason which can possibly be urged against the immediate adoption of this system on every inch of line is that of cost for additional cabins, machinery, and men. If the regulations and appliances by which this system is supposed to be worked, where it is in vogue, were carried out in their integrity there would be little room for complaint; the

most important point to secure is that the telegraph indicators are beyond possibility of misinterpretation; that they are facsimiles of the signals in use, in preference to words and pointers upon dials; and above all, that the station or cabin in advance should have absolute control over the telegraph semaphore at the previous cabin: bells and gongs should only be used to call attention or to indicate the description of the train signalled, but by no means to give "train on line" or "line clear" signals without a visible indicator; thus memory would not have to be relied on, for so long as a train was on the line between two block stations the telegraph semaphore would be at danger, and not be released until the train reached the advance station, and only by a signalman wilfully disregarding this could a collision occur.

Where stations are only five to seven minutes apart, computed at ordinary train-speed, the block can be established without loss of time between them, because such an interval may be considered sufficiently frequent for ordinary traffic; but when the distance equals a run of fifteen minutes, then for speedy transit an intermediate cabin at half-way would be requisite, so as to form two short stages; and where the traffic is very frequent, as on the Metropolitan lines, block cabins should only be so far apart that the time occupied by trains in running between them would be about equal to that between the dispatching of the trains; if any trains are timed to start every two minutes, then the cabins should only be a two minutes' journey apart.

Considering that few districts equal the Metropolitan, and that few stations are fifteen minutes apart, the outlay for establishing the "absolute block system" would be comparatively small, and the result would more than compensate for the outlay in a monetary point of view, and certainly in the saving of life and limb. One accident alone, such as now too frequently occurs (for they are not usually small ones), costs in compensation and repairs as much as would construct the requisite works for 200 miles. The last New Cross accident cost the Brighton Company 70,000*l.*

The mechanical contrivances for combining the movements

of signals and points, and for interlocking them, have been found of infinite value, in fact some of the large stations could not possibly be worked without. The uniform adoption of these appliances to every description of signal and point is most essential; to some extent it is doubtless a work of time, but the companies must be urged not to wait for continual accidents to necessitate an imperative demand being eventually made by the Legislature under public pressure for these improvements, but to proceed with them at once upon a large scale. It is not within the province of this pamphlet to attempt a recommendation of any particular system or systems of locking apparatus; there are very many, each possessing a special feature of its own; but the most serviceable are those simple but powerful in construction, and certain in locking, which should be perfectly effected before the lever is fully pulled over, and admitting of no play or spring whatever; the mechanism should be in view of the operator and capable of repairs without deranging the whole frame; for, as at heavily worked stations and junctions the friction and wear must be considerable, renewals will be frequent in any system, although precautions may be used to reduce it to a minimum. Immediately any wear in the sliding bars, slots, rocking shafts, or studs occurs, it will at once become apparent, for there will be a degree of play in the levers, and the locking will be uncertain. A skilful signalman can tell the state of the gearing to a great nicety by the *force* requisite to pull the levers over, and hence any serious defect may often be discovered and accident averted. This observation goes to prove that unskilful men, or men who have not had a good preliminary training first as assistants, should not be entrusted with a cabin.

One other matter of construction must not be overlooked. It has been recently asserted, that for facilitating operations under pressure of traffic some portion of the locking apparatus had been temporarily removed to allow the levers to be worked at discretion. Such a dangerous practice should be prevented by the parts of the mechanism being so fitted that no dislocation could be made by any of the officials. Some lever frames have a series of notches for the spring, which enable the signalman

to regulate the extent of the pull over; when the bars are longest he has to pull over farthest. Such a plan is not void of objection; there is, to say the least, an uncertainty in the result, and therefore any contrivance for this purpose is best apart from the locking gear or its immediate attachments, and one notch should be sufficient in the frames to hold each lever against any strain from a train while passing over the points. All systems are more or less subject to the difficulty of accurately compensating for the expansion and contraction which occurs in long lengths of jointed rods, necessarily used for far-off points and signals; and the opinion of experienced signalmen is, that no plan yet adopted gives absolute satisfaction. Wires are somewhat more manageable, as the operator can take in the slack, or let out, by means of the quadrant specially provided for that purpose, and thus with tolerable certainty meet every variation.

The requirements and recommendations of the Board of Trade now embody many of the modern appliances, and in the case of openings of new lines they are enforced; paragraphs 7, 21, and 22 of section B, fully provide for the collection of actuating levers at one convenient spot and there worked by a locking apparatus; clause 29 completely settles an old bone of contention by directing that in case of a signal wire breaking, the arm should fly to danger. Facing points are prohibited from general application, but when they are permitted, no provision is made that they should be locked with a rocking bar in addition to their locking with the signals; this is an absolute necessity, for more accidents occur at facing points than at any other part of the permanent way: the bars should be of sufficient length to take the longest wheel base of two couples, so that there is no possibility of the point springing between the passage of each pair of wheels; the bar should also extend in advance of the points some distance, in order that the wheels might lock them closely as they approached and before they actually came upon them, and in all situations foot indicators with lamps should be attached.

The operation of shunting as frequently conducted is most dangerous; the signalman has no evidence before him in his

cabin of the line being fouled at the points connecting the main and siding lines, and in a forgetful moment or from a misunderstanding may set the main line signals at all-right, when a goods train is in the way; the use of a gong as a communication between the shunting porter at the points and the cabin is very insufficient; a better plan would be to have a small box near the situation of shunting, connected by wire to a semaphore in the signal cabin, and worked as in the block system; during the shunting and while the line was fouled this semaphore should be set to danger; when the operations were over and the line clear, the arm would be released. The advance cabin should also have communication with that at the points, making it a block station in connection with the signal cabin. The points cabin should be securely kept under lock and key when not in use.

Hitherto no reference has been made to fog signals, but as an invaluable adjunct to the working of traffic during fogs, a few remarks here may appear desirable. The detonators generally used are almost identical with the original invention of Mr. Cowper in 1841: it consists of a small circular tin box filled with a fulminating composition and hermetically sealed; on the underside are two clips which open and clip round the head of the rail; they were first used on the London and Birmingham line, and subsequently by all the railway companies, but, as in the case of signalling, the rules for regulating their use are different on most of the lines.

Several inventions have been brought forward for laying the detonators over the rails by mechanical contrivance simultaneously with the action of the semaphores, but none have as yet met with any favour, so much really depends upon the nature and extent of the haze or fog that other than human agency is scarcely possible to be adopted with perfect safety; the chief points to be observed are to ensure a proper selection of men, to have distinct and uniform regulations, and perhaps, above all, to insist upon discipline.

The Appendix contains extracts from the existing regulations of the Board of Trade as to the opening of new lines, the circular issued to the railway companies in November last, together

with the replies of the Chairmen of the principal lines and Mr. Malcolm's summing up, which is a sufficient, able, and irrefutable comment upon those replies, clearly showing the true position of affairs between the companies and the public, and it simply comes to this:—Is the existing state of affairs to be tolerated any longer? are the travelling public satisfied to be constantly subjected to the increasing risk of being killed or maimed in a wholesale manner? If they are, and they will patronize being driven along the rails at absurd rates of speed at all points, past stations, sidings, and junctions alike, and with such protection as the companies are pleased to vouchsafe, then it is to be hoped that the Legislature will unasked, and for the common good, exercise its prerogative, and find itself, without outside aid, powerful enough to overcome the large railway interest in the House of Commons, and prevent public immolation. But if, on the contrary, the public are content to be driven at reasonable speed and with proper and sure precaution past certain dangerous localities, and will insist upon being protected by efficient signals, points, discipline among the railway staff, and a substantial rolling stock, then, seeing that the companies are evidently so averse to affording such protection liberally, although their Chairmen would have it appear and be believed that the contrary is the fact, the public must strengthen the hands of the Legislature, or if needs be, urgently press it to adopt means to compel the railway companies to carry out to the letter the regulations of the Board of Trade with some requisite additions, which would be best made under the award and direction of a practically and thoroughly experienced number of gentlemen, who might consistently form part of the existing "Railway Commission"; but without some such action the events of the past four months of this year are a gloomy and sure indication that things will go on much in the same way in which they have during the last few years; but it is to be hoped that the "Royal Commission" recently appointed upon the motion of the Earl De la Warr will find it needful, after careful investigation, to advise the Government to promote such a measure as may afford surer prospects of a better state of things for the future; and should they do so, they might

possibly further recommend that some consideration should be shown the companies, in respect of the large expenditure which they may be called upon to make, by the repeal of the existing passenger duties. No one doubts but that extensive and complete signalling improvements throughout a long line of railway will be costly and press somewhat heavily upon the shareholders, but the early ultimate result will be fewer accidents, less compensation, and an increased traffic return, so that in reality the improvements will be conducive to their own personal interests.

APPENDIX.

Extracts from the requirements and recommendations of the Board of Trade issued in February, 1872.

Section B.

Clause 6. Main signals and distant signals for each direction to be supplied; with extra signals for such sidings as are used either for the arrival or for departure of trains.

Clause 7. The levers and handles of switches and signals to be brought close together, into the position most convenient for the person working them. The switches to be provided with double connecting rods. The levers of the switches to be sufficiently long to enable the pointsmen to work them without risk or inconvenience, and not to be placed between the lines of rails. They should also be connected with locking apparatus.

Clause 8. No facing points to be put in, except on single lines, or at junctions, or in exceptional cases. At all stations and junctions the signals and points to be locked and worked as pointed out in No. 21.

Clause 9. All sidings connected with passenger lines to be supplied with a blind siding or safety point, with the points or point closed against the main line, and interlocked with signals.

Clause 20. The fixed signals attached to the gates of the level crossings should be placed in convenient positions for being seen along the railway as well as along the road. When a level crossing is so situated that an approaching train cannot be seen from a sufficient distance, distant signals (which may both be worked by one lever) should be supplied.

Clause 21. At all junctions home signals and distant signals for each line are required. It being necessary that a uniform system of signals should be adopted on all railways, the semaphore arms should, when there is more than one on one side of a post, be made in future, at stations and junctions, to apply—the first or upper arm to the line on the left, the second arm to the line next in order from the left, and so on. Clocks should be placed in conspicuous positions for the use of the signalmen.

Clause 22. The signal handles and the levers of the switches at junctions should be brought together under cover upon a properly constructed stage, with glass sides enclosing the apparatus. They should be so arranged, that while the signals are at danger, the points shall be free to move; that a signalman shall be unable to lower a signal for the approach of a train until after he has set the points in the proper direction for it to pass; that it shall not be possible for him to exhibit at the same moment any two signals that can lead to a collision between two trains; and that after having lowered his signals to allow a train to pass, he shall not be able to move his points so as to cause an accident, or to admit of a collision between any two trains. Every signalman should be able to see the arms and the lamps of his home as well as his distant signals, and the working of his points.

Clause 24. The junctions between the main line and any sidings which lead to

ballast pits in use, or which are employed for colliery or other purposes, should be protected by a home signal and a distant signal in each direction. The sidings should be so arranged that the shunting carried on at them shall present the least possible obstruction to the main line; and there should be a blind siding or safety point—the points or point to be closed against the main line and interlocked with the signals.

Clause 29. All signals which are worked by a wire should be so weighted as to fly to "danger" on the fracture of the wire.

Section D.

Clause 7. When a line is worked by telegraph, the telegraph huts should be commodious, and should be supplied with clocks, with record books, with separate needle for signalling the trains on each line of rails, and with an extra needle for other necessary communications between the signalmen. The telegraph instruments and signal handles should face the directions in which they work.

Circular issued to the Railway Companies from the Board of Trade.

Board of Trade, Whitehall Gardens,

Sir, 18*th November*, 1873.

Her Majesty's Government desire to call the earnest attention of the railway companies to the enclosed Report made to the Board of Trade upon the accidents which occurred on the railways of the United Kingdom in the year 1872, exhibiting as it does a state of things which, it is believed, has been not only continued, but aggravated during the present year.

It appears from the Report that a large proportion of these casualties are due to causes which are within the control of the railway companies. If it may be contended that the traffic on many lines has very greatly increased, and with it the risks of railway travelling, it is no less true that it is within the power of the companies to take care that the permanent way, the rolling stock, and the station and siding accommodation are kept up to the requirements of the traffic; that the officers and servants are sufficient in number and quality for the work to be done, and that proper regulations for their guidance are not only made but enforced; that pains are taken to test every reasonable invention and expedient devised for the purpose of preventing danger; and that such of those expedients as experience proves to be effective are adopted without undue delay.

In the face of the facts collected and analyzed by Captain Tyler, and of the numerous accidents of the present year (many of them the subject of Board of Trade inquiries), it is difficult to suppose that such is the case.

There can indeed be no doubt that methods of working and mechanical contrivances, the value of which has been thoroughly ascertained, have been too slowly introduced; and there is great reason to believe that sufficient provision has not been made for the safe working of the increased traffic by the enlargement or re-arrangement of stations and sidings and the laying down of additional lines of rail.

But whatever may be thought of these or other causes as contributing to the result, the present insecurity of railway travelling imposes upon the railway companies the grave responsibility of finding appropriate remedies for so great an evil.

In these observations I do not attempt to distinguish between the various companies, to all of which they do not in an equal degree apply.

Another subject which urgently requires attention is the frequent unpunctuality passenger trains.

The inconvenience, vexation, and loss caused to passengers by this breach of conditions upon which the companies profess to carry them, constitute in emselves a serious subject of complaint. But the evil arising from unpunc-ality does not end here. The service of the line is disarranged; the chances of cident are multiplied; and trains are forced, in order to make up for lost time, travel at excessive speed through complicated stations, or under other circum-nces where such travelling may be equally dangerous.

The returns made by the companies to the Board of Trade, under a recent Act, the accidents which happen to railway servants, show a lamentable number of sualties, often fatal, in proportion to the numbers employed.

It is no doubt true that many of these accidents are due to the negligence and shness of the men themselves and to the hazardous nature of their duties. But the same time, it is to be feared that the danger of their work is not unfrequently creased by the want of proper accommodation and appliances, or of suitable eans of precaution or protection; while sufficient pains do not appear to be ken to enforce upon them the observance of the regulations made for their fety.

The companies will feel the necessity of seriously considering the means of eventing so great a loss of life.

Her Majesty's Government are fully sensible of the difficulties incidental to ilway working in a country where the traffic is so great and so various, as well of the efforts which have been made by the railway companies, in many spects with remarkable success, for the accommodation of the public; but safety life and limb, which ought to be a paramount object, has nevertheless not been fficiently secured, and great and increasing dissatisfaction is the result.

Her Majesty's Government, therefore, reserving their own liberty to consider at y time the expediency of legislation upon any part of this important subject, ve deemed it their duty to call the attention of the railway companies to the hole question, in the hope that they, in whose hands the means of improvement ainly rest, will themselves make every effort to meet the reasonable demands of e public and of Parliament.

I request that you will bring this letter and the accompanying Report before ur Board.

I am, Sir,
Your obedient servant,
C. P. FORTESCUE.

To the Chairman of the
—— Railway Company.

From among the nineteen replies made by the Chairmen of as any companies, the following are selected:—The Chairman of the reat Western Railway writes:—

"GREAT WESTERN RAILWAY, PADDINGTON STATION,
SIR, "*December* 19, 1873.

"I have the honour to acknowledge the receipt of your letter of the 18th ult., ith the accompanying copy of a Report to the Board of Trade by Captain Tyler, on the accidents which occurred on the railways of the United Kingdom in the ar 1872.

"In compliance with your request, I have brought these documents before my oard, who have given to them the careful and attentive consideration which the

gravity and importance of their contents demand, and it now becomes my duty to submit to you the views of my Board thereon.

"I am desired by them to express, in the first place, their regret that it should have been deemed necessary by Her Majesty's Governmemt to address to this company a letter which contains—at least by unavoidable inference and implication—charges as to the conduct and management of the company's affairs of so grave and serious a character. How far these charges are borne out by the facts 'collected and analyzed' by Captain Tyler, is the question to which it will be my duty to address myself.

"Before, however, I enter upon the details of this inquiry, I think it necessary to premise a few words with reference to the alleged 'present insecurity of railway travelling.' Allow me, then, to invite your attention to the following brief statement of figures in relation to this company.

"During a period of seven years, including the year 1872, one passenger lost his life, and 247 sustained personal injuries (many of them being of the slightest possible character), from causes beyond their own control, while travelling in passenger trains over this company's lines. In the year 1872 (being the year specially referred to in Captain Tyler's Report), the company carried 32,800,000 passengers, and conveyed 11,777,072 tons of goods and minerals, running 18,390,047 train miles, and it was in this year that the one death of a passenger above referred to took place. Now while deeply regretting these accidents, and fully admitting it to be our duty to take every precaution in our power to prevent their occurrence, can it be said—in the face of figures such as the above—that the term 'insecurity of railway travelling' is fairly applicable to this company?

"I proceed, however, to examine the charges which this company is challenged to answer, and, in order that I may do so in the simplest and most intelligible form, I propose to follow the order of your letter, and to deal in succession with the several allegations and statements which it contains.

"In the second paragraph you state that a large proportion of the casualties referred to in the Report 'are due to causes which are within the control of the railway companies,' and you proceed to enumerate those causes as follows:—

"(1). That there is a want of due care that the permanent way, the rolling stock, and the station and siding accommodation are kept up to the requirements of the traffic.

"(2). That the officers and servants of the company are insufficient in number and quality for the work to be done, and that proper regulations for their guidance are not made, or, if made, are not enforced.

"(3). That pains are not taken to test every reasonable invention and expedient devised for the purpose of preventing danger, and that such of those expedients as experience has proved to be effective are not adopted without undue delay.

"1. With regard to the first point, it is of course difficult to meet general statements and allegations otherwise than by statements equally general. No specific cases are mentioned in which accidents on the railways of this company were to be referred to the neglect of the condition either of the permanent way or rolling stock. All, therefore, that it is possible for me to affirm is—and I do so with unhesitating confidence—that the maintenance of the company's permanent way and rolling stock in good repair, and in a proper and complete state of efficiency, is, with my colleagues and myself, and with the officers of the company, in their respective departments, an object of unceasing vigilance and attention, that no cost is spared to effect these objects, and that our permanent way and rolling stock will bear a comparison as respects their condition and efficiency with those of any railway in the United Kingdom.

"The question of 'station and siding accommodation' is a more complex and

difficult one. It cannot be disputed that these should be 'kept up to the requirements of the traffic'—but the fluctuating nature and extent of those requirements involve considerations perpetually varying with the variations of traffic in different localities. What amounts to 'sufficient provision for the safe working of increased traffic by the enlargement or re-arrangement of stations and sidings,' is a question dependent upon the special circumstances of each locality, and must be dealt with in reference thereto. The directors never hesitate to incur any expenditure which is called for by the demands of an expanding traffic, the reasonable accommodation for the public, whether as passengers or as traders, being inseparably bound up with the permanent interests of the company.

"During the last year (1872) the company substituted the narrow for the broad gauge throughout the whole distance from Swindon to Milford Haven (representing about 500 miles of single line), and they contemplate a similar operation in the ensuing year on other important and extensive parts of their system. In effecting these changes, as well as on other portions of the line, the enlargement and re-arrangement of stations and sidings, and the laying down, where needed, of additional lines of rail, have been and will be proceeded with. For the prosecution of this object additional statutory powers have already been obtained, and, as required, will again be sought by the company.

"2. With regard to the second point—the insufficiency of the officers and servants of the company in number and quality for the work to be done, I am placed in the same difficulty to which I have already alluded in dealing with the first point—*viz.* the generality of the allegations to which I am called upon to reply. No specific statement is made in any part of Captain Tyler's Report that, as regards this company, there is, in fact, any such insufficiency; and yet from the terms of your letter, I am compelled to suppose that, in the opinion of the Board of Trade, it really exists. All that I can do, therefore, is to say that for this general imputation there is absolutely no foundation. I affirm, on the contrary, that the staff of the company throughout its system is, both as to the officers and men, adequate and sufficient; and, as regards quality, I am satisfied that, having regard to the nature of the duties they are called upon to perform, there is no superior staff in any similar employment, or in any public or official service, in this country. The men are paid according to the highest current scale of wages for similar work; and while this company, in common with all other employers of labour, have to encounter as best they can all the difficulties which notoriously affect the present conditions of the labour market, they do from time to time make such additions to their staff as are called for by the requirements of traffic.

"I may add that, from the first establishment of the company to the present time, it has been their practice to give annual premiums for good conduct to signalmen, drivers, and others of their men upon whose care the safe working of the line mainly depends; and as the condition on which such premiums are given requires that, in each case, a whole year should pass without an adverse report, the fact that in every year upwards of 95 per cent. of the men obtain those premiums is the best proof of their skill and good conduct.

"As to the making and enforcing of proper regulations for the guidance of the officers and servants of the company, I have only to say that general regulations for such guidance are in fact laid down, and are strictly enforced. But I must add that, as the practical result of our experience, we believe the attempt to frame a code of precise and minute regulations, applying to every incident of a man's daily duties, would be mischievous rather than beneficial in its results, would diminish the sense of personal responsibility, and would, moreover, be found practically impossible to enforce.

"3. I come now to the third, and in some respects the most difficult, of the

questions raised in your letter—*viz.* the averment that this company have not taken pains 'to test every reasonable invention and expedient devised for the purpose of preventing danger, and that such of those expedients as experience proves to be effective are not adopted without undue delay.'

"That in the working of railway traffic 'safety for life and limb ought to be a paramount object,' and that, with this view, 'methods of working and mechanical contrivances, the value of which has been thoroughly ascertained,' ought to be introduced with reasonable promptitude, are propositions to which I and my colleagues fully assent. The question, however, is, whether this 'paramount object' has been neglected by the Great Western Company? and, by necessary implication from the terms of your letter, we are unavoidably driven to conclude that, in the opinion of Her Majesty's Government, it has. If we are right in this conclusion, then it becomes our duty, firmly, though with all due respect, to protest against the view which they have thus adopted.

"It would appear from Captain Tyler's Report that there are three 'methods of working and mechanical contrivances' to which the opinion thus expressed is intended to have especial reference—*viz.* (1) the arrangement of signals or points by means of the apparatus which is commonly known as the 'interlocking' system; (2) the securing of proper intervals between trains by means of what is known as the 'block telegraph' system; and (3) the system of continuous brakes.

"Now, with regard to two of these 'mechanical contrivances'—*i. e.* the 'interlocking' and the 'block telegraph' systems—we consider that, speaking generally, and subject to the remarks and qualifications which it will be my duty presently to make, their value, under certain circumstances, has been ascertained. Both systems have been adopted and are in daily use over a large part of the railways of this company, and are being introduced into other portions thereof, where necessary, as rapidly as the numerous other works of extension and improvement in progress thereon will allow. With regard to the first of the two, I may add that more than ten years since this company voluntarily, and by way of experiment, applied to a portion of their railway a system of locking which had been then recently invented. The result, however, may be considered as enjoining caution against the too ready acceptance and general application of what may appear, at first sight, to be valuable and important discoveries. The progress of scientific experiment and observation brought to light so many improvements in the system of locking that the company have been compelled to abandon the greater part of what they had thus done, and to interlock their points and signals on the new principle now in operation.

"But while admitting, without reserve, the expediency of adopting and applying every improved means of securing safety as and when proved to be reliable, I think it my duty, as one who has been actively engaged in the railway work of this country from its very commencement, and who has had daily experience in its working and in the conduct of the men engaged therein, to express my opinion that grave and serious dangers may arise from too great a reliance upon mechanical appliances as substitutes for manual labour. Speaking from my own personal observation and practical experience, I am satisfied that if this substitution is not adopted with caution and under due limitations we shall be only changing the nature of the risk, and may increase rather than diminish danger. Not only are there physical circumstances, such as atmospherical and other changes, which operate upon long lines of connecting rods and wires and interfere with and disturb their accurate working, but, assuming these to be in complete order, there is another risk arising from the diminished sense of responsibility and the feeling of false security which the universal adoption of mechanical appliances, supposed to *be perfect* in their operation, is apt to produce in the men, who must, after all, be

employed, and that in large numbers, to work them. I have already spoken of the general character of the officers and men who form the company's staff, and it is only due to them to say that they zealously and effectually perform the varied and often very difficult duties with which they are entrusted, the safe working of the line being not only in the interest of their employers, but also for the sake of their own credit their primary object. But human nature is, after all, fallible; and if the men are induced to believe that danger may be entirely prevented by mechanical inventions and expedients, their own vigilance will be very apt to be lulled to sleep.

"These remarks are more especially applicable to the 'block' system, the use of which involves the employment of an increased number of men with a consequent increase of the risk resulting from the liability to mistakes or neglect of duty. But, in addition to this, the engineman, who has hitherto had to depend on his own vigilance to look out, not only for the signals at stations, but for unexpected signals on any part of the line in consequence of some occasional and accidental cause, will naturally take for granted that the line is clear for him up to the next station, and will thus become less careful in his look-out.

"But, further, it must not be assumed that the adoption of these systems, however valuable they have been proved to be, will necessarily protect travellers from all risk. The records of the last year show the occurrence of accidents on lines worked on the 'block' system, and where the interlocking and connection of switches and signals in one box has also been in use. And it is a significant fact that the case referred to in a former part of this letter, as being the only one in which during the last seven years a passenger travelling by passenger train on the lines of this company lost his life from a cause entirely beyond his own control, occurred through the mistake of a signalman at a junction which another company had been authorized by Parliament to form with the line of this company, which had been specially examined and approved by an inspecting officer of the Board of Trade, where the points and signals were interlocked, and where the lines of railway belonging to this company were worked on the 'block' system.

"The only remaining invention which appears to be referred to in Captain Tyler's Report is that which is known as the 'continuous brake.'

"With regard to this, my colleagues and I are decidedly of opinion that no one of the systems as yet discovered can properly be designated as one of those 'mechanical contrivances' the value of which has been so 'thoroughly ascertained' as to justify its adoption by railway companies in general or by this company in particular. On the contrary, we think that, while in rare cases the use of these complicated contrivances might prevent an accident, they would in many more be the actual cause of accident.

"If any new system of continuous brakes is discovered free from the objections applying to all those hitherto invented and which experience proves to be really effective, there will be no indisposition on the part of this company to adopt and use the same, assuming, of course, that it will be applicable to the traffic of railways such as that of the Great Western Company. It is equally the duty and the desire of the company and its officers to assist in devising every practicable means of diminishing danger, but cannot reasonably be made matter of charge against them that they have not yet succeeded in discovering such a system as will really effect the desired object.

"The difficulty in which railway companies would be placed were the duty of inventing mechanical contrivances or adopting those the value of which has not been thoroughly ascertained thrust upon them may be illustrated by stating what has actually taken place with respect to the means of communication between passengers and guards.

"The railway companies were unanimously of opinion that none of the systems of communication which had been suggested could be depended upon, although about 160 different plans were examined and many of them tried. Eventually, the system known as the 'cord communication' was submitted to, approved, and sanctioned by the Board of Trade, and considerable expense was incurred by the companies in carrying it into effect. The Board of Trade, however, have called on the companies to abandon it, and to substitute some other in its place, while they do not suggest any which they themselves would consider satisfactory, the companies knowing of none that can be implicitly relied on.

"The next subject to which you refer, as urgently requiring attention, is the alleged frequent unpunctuality of passenger trains.

"In all your observations as to the importance of this subject I and my colleagues entirely concur, nor is there any which receives a larger or more constant share of our attention and that of the company's managing officers. The problem to be solved is, by what means can the desired punctuality be obtained without inflicting greater inconvenience and causing more serious evils than those which exist under present arrangements?

"The trains are timed with a view to meet the average requirements of the traffic, while absolute punctuality can only be obtained by so timing them as to provide for every contingency which can arise from the numerous and varied causes affecting railway traffic, and which are obviously beyond the control of the railway companies themselves. Among these I may enumerate the fluctuations of the traffic from day to day, the state of the weather, including the action of wind upon the trains, a greasy state of the rails, an unusual quantity of luggage, the putting on or taking off of horse-boxes and carriage-trucks—all, with other causes that might be named, involving more or less of detention to trains.

"These impediments and inconveniences are less sensibly felt where the traffic of a railway is exclusively, or in a great degree, a main-line traffic; but where, as in the case of this company, there are numerous branches for the accommodation of local traffic, and lines of other railway companies running into and in connection with the main line, the difficulty is much increased. Each one of these branches and lines pours its contribution into the stream of traffic, and an irregularity in any one disturbs the action of the whole.

"It cannot be denied that during the last year (1872) and the present, the trains of this company have been less punctual than they were in the two preceding years. But this difference has arisen principally, if not entirely, from the great increase which has taken place in the number of third-class passengers, travelling for the most part for short distances, and who (to the great advantage of the public) are now carried by, with few exceptions, all the company's trains, instead of as heretofore, only, or principally, in the Parliamentary trains.

"But we believe that the extent of the unpunctuality of this company's trains has been much exaggerated, as will appear by the following statement:—

"During the twelve months ending on the 31st of October in the present year (1873) the company have run, in the whole, 255,986 passenger trains, over a distance exceeding 8,500,000 miles. Of these trains 73·21 per cent. arrived at their destination punctually, or within five minutes of the time fixed by the time-tables; 12·32 per cent. arrived from five to ten minutes late; 9·64 per cent. from ten to twenty minutes late; 2·95 per cent. from twenty to thirty minutes late; 1·88 per cent. were above thirty minutes late.

"A large proportion of the trains that were thus irregular were run in connection with steamers and ferries; others were through trains from distant places, involving journeys of from ten to twelve hours in duration, and which when late

retained the local trains; while many of the trains carried passengers to or from as many as thirty branch lines or independent systems of railway.

"Among the evils arising from unpunctuality, you mention that trains when late are forced, in order to make up for lost time, to travel at excessive speed through complicated stations, or under other circumstances where such travelling may be equally dangerous.'

"So far as this company is concerned, I cannot admit the accuracy of this statement. I am not aware, and have no reason to believe, that any of its trains are run at excessive speed.

"I have already stated that this subject engages the constant and anxious attention of the directors and managing officers of the company, and we believe that absolute and unvarying punctuality could never be attained without such a limitation of the accommodation now afforded to the public, and the imposition upon them of so many restrictions as would give rise to just and far more serious complaints, than those of which we now hear. A considerable portion of the irregularities which occur in the working of the trains arises from the number which the company run in order to give the largest practical amount of through accommodation, and at the same time the quickest possible transit. To ensure absolute and uniform punctuality, the number of trains affording through communication would have to be reduced, and, coincidently with this, the *maximum* time that every train would require must be adopted as the standard for their time-bills.

"It remains only to notice your remarks on the subject of accidents to railway servants, which, as you state, 'show a lamentable number of casualties, often fatal, in proportion to the number employed.'

"Now the facts as to the year 1872 are as follows:—

"The entire number of persons in the company's employment, in connection with the trains and line, and exclusive altogether of offices, workshops, &c., was upwards of 18,000. Out of this number two were killed and twenty injured, owing to the negligence of fellow-servants; four were killed and twenty-four injured from causes not within their own control, and all the remaining casualties were caused entirely by the negligence and want of care of the men themselves.

"This is a matter which has constantly received the anxious and careful attention of the Board. Before the subject was discussed in Parliament, and before the passing of the recent Act to which you refer, it was, and it continues to be, the practice of the directors to have laid before them at each meeting of the Board a statement of all the accidents which have happened to any of the persons in their employment, however trifling the injuries received, and of the causes from which each arose; and it has been, and will continue to be, their earnest and unceasing endeavour to protect the men from accidents of every kind, whether arising from their own negligence or from other causes. We deeply regret that from the very nature of their employment our men are exposed to risk of life and limb, from which no care and no regulations can entirely protect them.

"In conclusion, it only remains for me to say, that while on all the matters referred to in your letter we are ready to make every effort in our power to meet the reasonable demands of the public and of Parliament, we cannot but deprecate that minute, and at the same time irresponsible, interference—with which we are not indistinctly threatened—with the management of an undertaking for the conduct of which we are to be held ultimately responsible, believing, as we do, that such interference, whether legislative or administrative, will prove as injurious to the interests and safety of the public as to the interests of our own shareholders."

Mr. E. S. Ellis, the Chairman of the Midland Railway, writes:—

"MIDLAND RAILWAY, BOARD ROOM, DERBY,

"SIR, "*December* 18.

"I have as desired brought before the Board of Directors of the Midland Railway Company your letter of the 18th ult., enclosing a copy of Captain Tyler's Report upon Railway Accidents for the year 1872.

"I have first to express regret that Her Majesty's Government should consider that a large proportion of the casualties were due to causes within the control of the directors—an opinion in which my Board cannot concur so far as the Midland Company is concerned.

"You state that your observations are not intended to apply to all railway companies in an equal degree, and it is therefore difficult to know to what extent they are intended to apply to the company I have the honour to represent.

"With regard to the frequency of accidents, an examination of the Reports of the officers of the Board of Trade will show that the number of casualties in 1872 exhibits a decrease on a fair comparison with former years; notwithstanding the very largely increased traffic and the constantly growing requirements of the public—a result which could only be obtained by the closest care and watchfulness on the part of those entrusted with railway management.

"It is possible that much of the alarm which has given rise to your letter has resulted from comparisons drawn from imperfect *data*. The Act of Parliament passed in 1872 requires accidents to be reported which were not reported in previous years; many of these do not involve danger to passengers, but, in consequence of their being now for the first time included in these Reports, a feeling of alarm has been created which with a full knowledge of the facts would not have existed.

"I would here beg to draw attention to the concluding paragraph of Captain Tyler's Report upon the accidents during the year 1870, in which he says:—

"'There is no doubt of the general safety of railway travelling as compared with other means of locomotion, and it is certain that the most vivid imagination could not have supposed, a few years since, that so many passenger journeys could be performed, and so much material conveyed, at such speeds with so high a degree of safety.'

"In comparing the result of that year's working with the year 1872, I find that in 1870 the number of passengers killed from causes beyond their own control amounts to 1 in 4,651,000, against 1 in 17,609,784 for the year 1872, which is itself evidence of the continued care and watchfulness of Railway Boards.

"Upon the Midland Railway during the year 1872 there were, with the large number of 21,308,639 passengers, exclusive of season-ticket holders, who travelled on their line, only two fatal accidents to passengers. One of these accidents was caused by a passenger jumping from a train, and the other by a door having become open from some unexplained cause after the train had started.

"Without going *seriatim* through the various points raised in Captain Tyler's Report, I may say that, for many years past, the improvement of the permanent way has had the unremitting attention of my Board; the weight of the rails and chairs has been materially increased; large portions of the line have been relaid with steel rails, and all modern inventions which experience has shown to be improvements have from time to time been adopted, and the directors believe that the permanent way of the Midland Company is in a very satisfactory condition.

"The directors have also spared neither pains nor expense in maintaining the rolling stock of the company in the highest state of efficiency.

"With regard to the block system for working the traffic, the interlocking of

points and signals, and the provision of sufficient accommodation for the increased traffic of the railway, I have to observe that so far back as the year 1864 the Board instructed their officers to commence the establishment of the block system upon their main line, and they have, from time to time, ordered its application to other portions of their system, resulting at the present time in the block being in operation over nearly 500 miles of the most important portions of the railway; and the further extension of it is being proceeded with as fast as materials can be obtained and the work executed.

"Similarly, steps have been taken with respect to interlocking and safety points; and no efforts have been, or will be, spared on the part of the Board to carry out the views which they have so long entertained with regard to these subjects.

"I beg here to draw your attention to the fact, that after a full inquiry by a Committee of the House of Lords in the last Session, as to the extent to which railway companies were adopting means of safety for working the traffic, that committee reported as follows:—

"'Relying on the great exertions recently and very generally made by different railway companies to extend the block and interlocking systems and the improvements now in progress, the committee recommend that the Bill (for rendering the block system and other precautions compulsory) should not be proceeded with during the present Session.'

"You call attention to the necessity that station and siding accommodation should be kept up to the requirements of the traffic; the officers and servants being sufficient in number and quality for the work to be done, and proper regulations for their guidance being, not only made, but enforced; pains being taken to test every reasonable invention and expedient devised for the purpose of preventing danger, and such of those expedients as experience proves to be effective being adopted without undue delay.

"The following figures show that very great attention has been paid by the Midland Board to the subject of providing increased accommodation for their traffic during the last few years:—

"The amount expended during the six years ending June 30, 1873, upon the enlargement of stations, sidings, buildings, and establishing the block and interlocking system was 1,766,059*l.*

"The amount expended during the same period on widening existing lines was 1,233,635*l.*

"The amount expended in duplicating the line between two common points was 2,390,866*l.*

"The amount expended in increasing the number of engines, carriages, and wagons was 2,558,265*l.*: making a gross outlay of 7,948,825*l.*

"This expenditure is irrespective of the construction of new lines, and is still going on. At the present time the sidings upon the Midland system exceed 700 miles in length.

"As regards the sufficiency of the staff for the proper conduct of the traffic, I may state that while the gross receipts from all sources of traffic during the same period have increased from 2,804,436*l.* to 5,026,102*l.* per annum, being at the rate of 79 per cent., the number of servants has increased from 15,882 to 30,006, or 90 per cent., and the salaries and wages paid from 871,728*l.* to 1,852,136*l.* or 112 per cent.

"In selecting the staff great care is exercised in obtaining men of good character and properly qualified for the duties they have to perform; but Captain Tyler has shown in his Report that it is impossible with so large a number of men to secure entire immunity from accidents.

"The directors have at all times been willing to test new inventions and to

adopt such as are found upon trial to be beneficial. Among such inventions continuous brakes may be mentioned as an example. Several different descriptions of these have already been tested by the Midland and other companies, and others are now in course of trial. These experiments will doubtless result in the adoption of the one found to be the most efficient.

"It is highly important that all the companies should adopt the same plan of brake, otherwise great inconvenience would be experienced at junctions in exchanging carriages between the various companies, and in this view it is essential that the subject should be most carefully considered before an expenditure is incurred which subsequent experience might prove to be entirely fruitless.

"The question of the unpunctuality of trains has very largely engaged the attention of my Board, and great expenditure is now being incurred by this company to mitigate it by providing separate lines of rails on the more crowded portions of the system for passenger and goods trains.

"My Board will continue their efforts to reduce the delays as far as possible, but it is mainly a question for the public whether they prefer the existing state of things to greater punctuality at the expense of reduced speeds, fewer through bookings and communications with branch lines and the systems of other companies, and greater restrictions at stations.

"The maintenance of the present postal service throughout the country may also be involved in this question.

"I have now noticed the various points mentioned in your letter, and beg to assure you that I and those who are associated with me fully recognize, and do not seek to escape from, the responsibility which devolves upon the directors and officers of every railway, of sparing neither expense nor effort in the future, as we have not spared them in the past, to secure the safety of both passengers and servants as the first consideration, as well as to maintain the service in the highest state of efficiency.

The Chairman of the London and North-Western Railway writes as follows:—

"Euston Station, London, N.W.,

"Sir, "*December* 10.

"I have the honour to acknowledge the receipt of your letter of the 18th of November, addressed to me as Chairman of the London and North-Western Railway Company, which, with its accompanying Report, I have as requested laid before my Board.

"I regret that in this letter you should, by implication, have made the gravest possible charge against those who manage the railway companies of this country —that of neglecting the means which might be at their command for securing the safety of the public.

"I regret it not only because such an imputation is unjust towards those gentlemen who co-operate with me in the management of this great enterprise, but because it may give to my remarks a controversial form; whereas my only wish is to explain the difficulties we have to encounter, the measures we have taken to overcome them, the efforts we have made to afford every facility and accommodation to the public, and, above all—to secure their safety, which, to say the least of it, is as pressing a cause of anxiety to me and my colleagues as it can possibly be to Her Majesty's Government.

"I may observe that the figures given in Captain Tyler's Report scarcely bear out the allegation that the companies have not kept pace in their arrangements with the requirements of their increasing traffic. The number of deaths of

passengers 'from causes beyond their own control' shown in the Report has fallen from an average of 1 in 4,700,000 in the three years ending in 1849, to 1 in 11,000,000 in the six years ending in 1872—the year 1872 itself giving an average of 1 in 17,800,000. It would thus seem that so far the exertions of the companies have been attended with beneficial results, notwithstanding the rapid growth and increasing complication of the traffic, and our best efforts shall still be directed to further diminish this average.

"During the year 1872, 37,000,000 passengers were conveyed on this railway, and from the above-mentioned Report it appears that no fatal accident of the description referred to occurred.

"Alluding to your observation on the accidents of the present year, although the number of passengers has increased, there has been, so far, only one fatal accident of the same class, and it may be fairly doubted whether the blame even in this case rested with the company. Of course, in my remarks I do not include the melancholy accident at Wigan, which, after the most searching investigation —official and otherwise—has not been proved to result from any defective arrangements of the company.

"The number of accidents reported has increased in 1872 over what it was in 1871; but formerly none were reported except those involving serious injury to passengers, whereas the list has been increased by including collisions and break-down of goods trains, &c., involving no risk to passengers, and by accidents, however trivial, from every cause, including those to companies' servants as well as the public, in accordance with the provisions of the Act of 1871. These were not formerly brought into public notice, although they have always occurred. Their publication without sufficient explanation has produced, as it was calculated to do, an anxiety in the public mind which would not have been excited had the comparison between different years been made on the same basis.

"I proceed now to point out what we have done and are doing to further promote the safety of passengers travelling on our line of railway.

"As regards accidents arising from defects in the permanent way and rolling stock, I do not know of any precaution we have neglected. We endeavour at any expense to obtain the best materials; the gentlemen in charge of the permanent way and rolling stock are of proved scientific skill, second to none in the engineering world, and in accordance with their instructions keep their respective departments in the highest state of efficiency. We have increased the weight and strength of our carriages to nearly double what they were at first, and that alone has materially diminished the risk of injury to passengers. We have applied on almost all our passenger carriages a system of tyre-fastening, which so far has done away with any danger from breakage or loosening of the tyres. For many years we have been, and are still, relaying the old lines with rails of the heaviest pattern in use, principally steel, and with the most approved fastenings. That failures will sometimes occur is known to everyone who is conversant with the subject—but every means within our power is taken to guard against them.

"With reference to the introduction of the block telegraph and interlocking systems, much detailed information was laid before Parliament last Session on Lord Buckhurst's Bill for the prevention of accidents. The Committee of the House of Lords, after full inquiry, reported in the following terms:—

"'Relying on the great exertions recently and very generally made by the different railway companies to extend the block and interlocking systems, and the improvements now in progress, the committee recommend that the Bill should not be proceeded with during the present Session.'

"For several years these systems have been introduced gradually on the London and North-Western lines. This company began, I believe, before any other to

work the trains on part of their line by telegraph, on what was afterwards termed the Permissive Block System, which was considered a great improvement at the time. Out of this the 'Absolute Block System' has grown, and been applied to a great part of this line, as it commanded more general approval.

"This company was the first to introduce, on a large scale, in the year 1864, the system of interlocking points and signals patented by Mr. Saxby. Many modifications have been, and are still being, introduced into it, and are from time to time adopted at all the principal stations; as its efficiency has been better proved, the system, particularly of late years, has been applied as the apparatus, which is very complicated, could be provided. This company also led the way in adopting a recent improvement at facing points called a locking bar, which has been already extensively used, and is being further applied as fast as possible.

"The sum expended on the block and interlocking system has amounted, for some years past, to an average of fully 80,000*l.* per annum, and that sum will be exceeded this year. To show the magnitude of these works, they have involved the erection and construction, up to the end of 1872, of upwards of 13,000 new signals, with the corresponding apparatus.

"Before leaving this part of the subject, I would again quote from the 32nd paragraph of the Report of the Committee of the House of Lords on Lord Buckhurst's Bill:—

"'A perfect system of interlocking requires many complicated arrangements, such as refuge sidings, alteration of signal stations, and other changes, which, especially where the junction unites two lines under the management of different companies, involve matters of difficult adjustment. The evidence will explain more fully the cost and complex character of these arrangements.'

"The question of continuous brakes has recently been brought prominently before the public, and is a good example of the difficulty of dealing with mechanical inventions on a large scale. For many years we have been engaged in experiments on this subject. We have tried a large number at the company's expense, and have given every facility to inventors to use our plant and lines to try their experiments whenever there seemed any prospect of success. We purchased two patents—one as long ago as the year 1863—and applied them to some of our trains, but had not found them in practice suitable for all kinds of traffic. The public is kept well informed of the merits of such inventions—it is left to us to find out their defects; and that can be done only by long trials under the varying circumstances of our traffic. We must ascertain whether they can be adapted to our existing plant, which was not designed for them; whether they can be disconnected and fitted securely in the conduct of a busy traffic, and frequently at night; whether they are liable to fail, and many other circumstances. And when I mention that we have some 4000 vehicles, exclusive of engines, used on passenger trains, all, or nearly all, of which would have to be fitted with the apparatus to make it generally applicable, it is obvious that this cannot be done —especially in the face of a constant supply of new inventions and improvements—without much time and consideration.

"We have recently adopted a modification of one of the former patents, and so far we consider it satisfactory. It is applied to our metropolitan trains, to the Irish mail, and to some other main-line trains; should it continue to fulfil our expectations, we shall extend its use.

"Her Majesty's Government must be aware, from their experience at the Admiralty, of the extreme difficulty of keeping a large plant up to the level of modern inventions.

"It should be observed with regard to all these mechanical appliances, whether *brakes or interlocking*, or any others which are believed to meet some particular

danger, that they are liable to create a feeling of confidence in the men, who are therefore naturally induced to risk more than they would otherwise do. Hence an accidental failure in one of them may produce more danger than their absence, and they should never be generally adopted until after the fullest trial of their certainty of action, not only with trains specially prepared for an experiment, but under the varying circumstances of general traffic.

"In order to show we have not overlooked the necessity for doubling lines and enlarging stations and appliances to meet the increasing traffic, and have not spared money for this purpose, I need only say that during the last five years the company has, on its old lines, expended more than 4,000,000*l.* in doubling lines, enlarging stations, increasing sidings, &c., in addition to nearly 2,000,000*l.* spent on new lines, of which the greater part was laid out to relieve the traffic of existing lines—forming altogether about 1-9th of the whole capital of the company expended in works—beside an expenditure out of annual revenue which has averaged, during the last two years, nearly 100,000*l.* per annum, almost entirely on refuge sidings and interlocking points.

"The laying down of additional rails upon the more busy portions of the line has long had the attention of the directors; a third line was accordingly, several years ago, completed between London and Bletchley; a fourth line will shortly be opened, and in order to continue these lines into Euston Station, powers were obtained in last Session to construct a duplicate tunnel for two lines of rails under Primrose Hill.

"Plans are now preparing for further extending these two additional lines to near Northampton.

"A third line has recently been opened between Rugby and Nuneaton, on the up side, for the goods trains, in order to facilitate the passage of the night mails.

"Two additional lines are already in course of construction between Stafford and Crewe, and the Board are proceeding with arrangements for filling up the intermediate portions, so as to complete four lines of rails over the whole distance between London and Crewe.

"Carrying out the same principle, alternative railways have been in several cases constructed, such as the Whitchurch and Tattenhall, for the purpose of conveying the traffic of South Wales with Birkenhead and Chester without passing through the busy station of Crewe; the Runcorn Bridge and its necessary approaches costing more than 500,000*l.*; the Lancashire Union lines, which, with the doubling between Liverpool and Huyton and the new lines from near Manchester to Wigan, make duplicate communications between Liverpool, Manchester, and Wigan and the North. Several branches and tunnels, especially a tunnel 3¼ miles long in Yorkshire, originally made for single lines of rails, have also been doubled to meet the public requirements.

"Many of the large stations have been rebuilt and materially enlarged to meet the increased traffic, and as instances in point, I may mention Euston Station, the area of which has been doubled. Stafford and Crewe stations have both been constructed three times, and greatly enlarged on each occasion, and we have just now settled plans for a further enlargement of Crewe at a cost of about 100,000*l.*

"Lime Street Station, Liverpool, has also been built three times, and we are now doubling its area at a cost of upwards of 500,000*l.* Manchester, Birmingham, Warrington, and many other stations have been reconstructed and enlarged in the same way at enormous cost. Carlisle, Preston, and Bolton stations are in course of being rebuilt and enlarged. Similar works have for some years past been going on, and are now being carried out on almost all parts of the line as rapidly as the state of the labour market and other circumstances will permit, and others are in contemplation.

"On this, as on all railways in the kingdom, the stations were laid out originally on what was then considered an extravagant scale, but in the great majority of cases they have now proved insufficient, and, as works of different kinds naturally gathered round the stations, the task of enlarging them has become not only excessively expensive, but very difficult, owing to the vested interests concerned, which frequently cannot be dealt with without Parliamentary powers, obtained after great delay. Wherever further accommodation seems desirable, we endeavour to overcome these difficulties.

"The company employs 40,000 men, of whom about 16,000 are directly connected with the service of the trains. We have met all reasonable demands both for increase of wages and diminution in the hours of work. Among so many there must always be some who misconduct themselves, even under the most vigilant superintendence; yet, making all due allowance for the difficulty of the service, we have no reason to be dissatisfied, either with the conduct of our men or the class from which they are taken, and I believe that there is no class of men more steady or sober than railway servants. None are taken into the service except on approved character and after special examination as to their education and fitness for the duties they have to perform, but the present state of the labour market has rendered it unusually difficult to maintain the supply of suitable men.

"The number of accidents to railway servants is a matter of painful anxiety to all concerned in railway management. Some parts of the service must necessarily be dangerous, and it too frequently happens with them, as with miners and others engaged in a dangerous trade, that the presence of danger produces a reckless disregard of the most obvious precautions for their own safety. We have endeavoured to frame and to enforce the rules which experience has shown to be most calculated to guide the men in the performance of their duties; but it is impossible to frame rules so minute that they should meet every contingency, and much must be left to the judgment of the men themselves.

"The only other point I have to notice is the irregularity of the trains, which is a great evil, but one with which it is very difficult to deal.

"The times fixed for arrival and departure of passenger trains at the various stations are, so far as the companies can ascertain, the most convenient for the public, and are such as can be maintained under ordinary circumstances, but there is always a liability to occasional derangement by extraordinary influx of passengers, large quantities of luggage, foggy and stormy weather, slippery rails, connections with other lines of railway or steamboats, and by other causes. On all railways where the traffic is large and of a mixed character a delay to one train necessarily causes delay to others.

"These delays of passenger trains very seldom arise from want of engine power, but from other causes such as those before stated, and they are at present considerably increased by the introduction of the block system; but this cause will, I hope, soon be remedied, as the men employed in working become more practised in its use, and some additional block stations, refuge sidings, and other works are provided, the necessity for which could not be made known except by the result of working.

"If it were held that companies were to guarantee, under all circumstances, the exact times stated in their books, the whole system of railway travelling must be altered and many conveniences now enjoyed by the public withdrawn.

"Companies like the London and North-Western could relieve their trains very much and ensure greater punctuality by adopting the Continental system at their stations, by running fewer through carriages, and by limiting their trains, but they would thus deprive the public of a convenience which is now much

appreciated, and necessitate a change of passengers and luggage at the several junctions as well as involving disappointment should the train not be able to take up all the passengers.

"The only other alternative would appear to be to reduce the trains to a speed which would give a margin sufficient to cover all exceptional circumstances. This, however, would so completely revolutionize the habits of the travelling public and involve so great a loss of time to business men, that the system would give rise to greater complaints than those now made.

"We have earnestly endeavoured to secure punctuality under the present system, and have divided the principal trains on the main line to lighten them, a plan which is still further adopted in the busy season. We are most unwilling to restrict the public convenience, but if we are called upon to carry on the service under conditions which are incompatible with the accommodation now given, we may be forced to do so.

"An impression seems to prevail in some quarters that railway companies for their own advantage run trains at too high speeds, and so put the public in danger. This is an entire misapprehension. High speeds are a positive disadvantage to the companies. There is more expense connected with them, and the interests of the companies themselves would be much better served by slower trains. The number of fast trains has been furnished in the interest and to meet the requirements of the public, much of the business of the country is promoted by such rapid communications; but it would save considerable expense to the companies to discontinue them. It, however, has yet to be shown that trains are running at speeds which are unsafe, but should Parliament think proper to arrest the development of railway progress and reduce the speed, it would be a gain to the companies.

"I have, Sir, replied to the different points in your letter. I have endeavoured to show what we are doing and what, in the judgment of those most conversant with the working of these lines, can be done on the points to which you refer.

"I and those associated with me have for many years been charged with the management of the largest railway enterprise in England, and we have tried to develope that system as far as possible and to give the public, whom we serve, all the accommodation that the means at our command would allow. We have organized a service which, although rivalled by some of our neighbours in this country, is, for the accommodation given to the public, in speed, number of trains, and general facilities, without example in any other part of the world. To accomplish this result, we have been obliged constantly to modify our arrangements and to introduce additional appliances, as well as frequently also to exact greater services from the means at our command. I should be the last to assert that in carrying out plans, in many respects so new and so unlooked-for when railways were first organized, we have not made mistakes; but we have endeavoured to rectify them as experience has pointed them out, and we have never neglected, to the best of my knowledge, any proved precaution which would conduce to the safety of the public, while striving to do the best for its service. The services thus carried on have been of incalculable value to the prosperity of the nation, and we can only regret that, on what we submit to be incomplete information, we should have met with the disapproval of Her Majesty's Government.

"I have the honour to be, Sir, yours faithfully,

"RICHARD MOON, Chairman.

"The Right Hon. C. P. Fortescue, M.P.,
President of the Board of Trade."

The following was the reply of the London and South-Western Company:—

"SIR,

"I have the honour to acknowledge the receipt of your circular letter, dated the 18th of November, addressed to me as chairman of this company, by which you call the earnest attention of railway companies to a Report by Captain Tyler to the Board of Trade upon the accidents which occurred on railways in the year 1872.

"The South-Western Board is gratified to observe, from Captain Tyler's Report, that in the year 1871 no accidents occurred on this railway which called for an inquiry by the Board of Trade; and in the year 1872, although three accidents were investigated, these were comparatively slight and unimportant.

"These three accidents are thus described in the Report:—

"No. 1. '23rd February.—An up passenger train came into collision with the tender of a shunting engine at the Guildford Station. One passenger was slightly injured. The engine driver of the shunting engine failed to sound the proper signal whistle to indicate to the signalman in the yard where he wanted to go. An additional signal for this portion of the line was required to avoid further risks in employing hand signals for the signalling of trains.'

"Although the Guildford Station had been previously well supplied with signals and interlocking apparatus, several additional signals have, as suggested, been erected for extra precaution.'

"No. 2. '20th May (Whit Monday).—An up train from Barnes came into collision at the Waterloo Station with the empty carriages of a previous up train, which was being backed out of the platform line, on which it had arrived. Two passengers were injured. The engine driver of the empty train had mistaken the waving of the arm of the signalman, who was beckoning up another train, for a signal to back his train. It was recommended that the line on which the empty train was being backed should have a distinct signal provided for it, connected with the facing points and interlocked with the up signals.'

"Previous to this occurrence, a very considerable expenditure had been incurred in erecting a large over-bridge signal box, with all modern appliances for interlocking signals and points, and an extensive traffic has been for many years safely worked in the Waterloo Station. But a further large expenditure has been, and is still being, incurred in erecting additional signals and making other improvements on that station, although it is practically impossible to provide by fixed signals for every shunting operation in a large station.

"No. 3. '26th December.—An up Southampton goods train came into collision with an up Portsmouth goods train which was standing at the platform at the Woking Station. The evidence was conflicting, but the engine driver of the Southampton train could hardly have shut off his steam and applied his tender brake at the distant signal which was at danger, without stopping the train before it reached the platform, and it was supposed that the engine driver must have been under the influence of drink. A brakesman of one of the trains was killed.'

"The line at Woking Station for a considerable period previous to this accident had been worked under the absolute block system, and the Southampton up goods train ran considerably past two signals, both of which were at danger, before reaching the station.

"These three accidents, none of which can be said to have resulted from any fault of system, were all that occurred in the year 1872 on the London and South-Western Railway, 664 miles in length. During that year trains ran over the railway to the extent of 7,076,341 train miles, and 16,136,559 passengers (ex-

clusive of 5500 season-ticket holders travelling almost daily) were conveyed, three only of whom were, as above mentioned, injured, and two of those three slightly.

"While the directors would have been better satisfied if, like 1871, the succeeding year had been quite free from accident, they are thankful for the comparative freedom from serious accidents enjoyed by the South-Western Railway in that year, as perfect immunity from accidents cannot be reasonably hoped for with such a length of railway and so large a train mileage.

"This company has for many years past with considerable success kept constantly in view the importance of adopting every practical method for securing safety in the working of their railway, and with respect to the absolute block system, upon the importance of which Captain Tyler so much insists, it was adopted without 'undue delay,' and out of the 664 miles of this railway 419 miles are already worked upon that system; 88 miles additional will soon be brought under its operation, and next year the absolute block system will be further extended.

"It will not be denied that when the idea of maintaining a positive interval of space, instead of an uncertain interval of time, between following trains was originally conceived, the elaborate mechanical and electrical appliances now found absolutely necessary to secure an interval of space were not known or dreamt of. It would have been almost a disaster if the block system, as at first rudely and vaguely conceived, had been hastily adopted, and I am justified in saying that any time supposed to have been lost before its adoption has been most amply redeemed by the almost perfect block system matured and successfully worked out by the railway companies.

"The interlocking of points with signals, another matter on which Captain Tyler places great importance, has also been carried out by this company to a very large extent, and is in course of further extension. It is already in operation at all our junctions and most important stations.

"The other matters to which your letter calls attention, as necessary for safety, and within the control of the companies, are:—

"First. The maintenance of the permanent way, the rolling stock, and the station and siding accommodation in a condition to meet the requirements of the traffic.

"This company has adopted every known means for strengthening and improving the permanent way; a very large expenditure has been incurred in enlarging the station and siding accommodation, and this work is still proceeding without cessation.

"Within the past seven years, in addition to the cost of the ordinary maintenance of the permanent way, 250,000*l.* has been expended upon its strengthening and renewal.

"The directors have thus been enabled to keep the permanent way and the siding and station accommodation fully up to the requirements of the increasing traffic.

"As regards the rolling stock, the same course has steadily and successfully been pursued. The South-Western Company was among the earliest, if not the first company, to adopt the modern improvements upon the tyres, wheels, axles, and axle-boxes of engines and carriages, and have had in successful operation for several years inventions not yet generally adopted. In fact, the only modern invention, with a view to additional security in the working of railways, not yet adopted by the South-Western Company is a continuous brake upon trains.

"The question of increased brake power on trains has not, however, failed to receive the careful consideration of the directors. From an early period this com-

pany has had in operation Newall's connected brake, whereby a guard is enabled to apply brakes to more than one carriage in a train. Some of the engines have also been fitted up according to the plan of M. Le Chatelier, whereby it is proposed to give additional power to the engine driver to stop a train in motion.

"My colleagues, however, are, with our manager and myself, of opinion that further experiments are necessary previous to the adoption of a continuous brake in trains. These experiments are making progress. We think, too, that it is a question deserving of greater attention than it has yet received, whether the occasional benefit which may be derived from a continuous brake is sufficient to compensate for the increased risk arising from that continual, and (which is of equal importance) unequal wear and tear which the constant use of a continuous brake wherever a stoppage or a slackening of speed is required, must, especially in the case of fast trains, produce upon every tyre, wheel, and axle in each train so fitted, as well as upon the rails. The difficulties which must arise in maintaining the accuracy of the brake blocks on the wheels of each carriage, the necessity for the frequent renewal of these blocks, and the uncertainty of the power to be applied to them, are matters also for very serious consideration.

"Second. The punctuality of passenger trains.—The directors have at all times been most desirous of securing the punctual working of trains, but daily experience has shown the practical impossibility of obtaining, under varying circumstances, the absolute punctuality of all trains.

"Among the more important causes of unpunctuality, so far as it exists on the South-Western Railway, may be enumerated:—The late arrivals, through weather and other causes, of steam-packets from the Isle of Wight; the late arrivals at the numerous junctions upon the South-Western system of trains worked by other railway companies; the handling of large quantities of luggage; the conveyance of large foreign mails; and the attaching and detaching at stations of horse-boxes and carriage trucks. And upon the suburban lines the necessity, in common with all similar lines, for making the arriving trains form also the outgoing trains, from which it inevitably results that the detention from any cause of one train affects the punctuality of other trains; also the necessity, felt by nearly all the railway companies in London, for marshalling and arranging trains at a distance from the chief passenger station, as occurs in the case of this company at Clapham Junction.

"I fail to see that any of these causes are remedial as defects of system. They can only be kept at a *minimum* effect by unceasing vigilance in respect of the ceaseless variety of details with which, along with other companies, we have daily to contend.

"But while it cannot be controverted that want of punctuality is or may be a cause of inconvenience, I may be allowed to refer regarding it to Captain Tyler's remarks in his Report for 1870:—'Unpunctuality ought not to be even an excuse for, much less a cause of, accident, and a railway that is so worked as to be safe for punctual trains only cannot be considered safe for ordinary railway traffic.'

"Third. The adoption of measures for preventing accidents happening to railway servants, in the performance of their duties.—Such accidents are, no doubt, too numerous; but experience has shown that most of them are due much more to the rashness and haste (I would rather call it the over zeal) of the men employed than to the hazardous nature of their duties. The directors have issued very numerous cautionary instructions to the servants of this company. A copy of the last, issued so recently as the 5th of September, is enclosed herewith, from which you will not fail to observe in what detail unnecessary risks are reprobated and how much extreme caution is inculcated.

"*It* cannot, however, be denied that neither railway work nor railway travel-

ling is, or can be, altogether destitute of a degree of risk, but I venture to adopt the language of Captain Tyler in the conclusion of his Report on accidents for 1870, as I believe it to be strictly accurate, and also a conclusive testimony to the great care and constant attention which has been bestowed by railway officers and servants of all grades (I am only entitled to speak for our own) in the performance of their onerous and responsible duties towards the companies and the public. Captain Tyler states :—

"'There is no doubt of the general safety of railway travelling as compared with other means of locomotion, and it is certain that the most vivid imagination could not have supposed a few years since that so many passenger journeys could be performed and so much material conveyed at such speeds with so high a degree of safety, and the more intimately the numerous risks incurred at each mile from human agency or defective materials are known and understood the more does the marvel increase.'"

Extracts from the reply of the North British Company.

"The North British system, extending to 836 miles in length, is made up of a number of railways, which were amalgamated into one between the years 1862 and 1865. Each of these companies had, prior to the union, its own patterns of plant, rails, chairs, signals, &c., and it is evident to anyone that a whole system—the growth of years—cannot be changed and made uniform at once. One of the first acts, however, of the reconstituted Board, upon accession to office in 1867, was to fix uniform patterns for plant, way, &c., and ever since this has been steadily kept in view, and both plant and way are in a condition very superior to what they ever have been. The directors are laying down steel rails in many places, and within the last two years are strengthening the line with extra chairs and sleepers.

"The directors spare no pains or expense in procuring the best material for the manufacture of the axles used in the company's rolling stock. In the month of March last year, the Board made a regulation prescribing the dimensions of wagon axles to be used on the railway, and limiting by precise and definite rules, the load of wagons according to these dimensions. These regulations, which apply alike to the rolling stock of the company and to traders' wagons, were framed with the express object of securing safety, and are strictly enforced.

"Of the several inventions for the secure fastening of tyres to wheels there appear to be three which have met with general approval. The company have adopted all of these, and apply one or the other of them to all their new and heavily repaired coaching stock.

"It may be generally assumed that the couplings of passenger carriages rarely, if ever, fail. The couplings of goods and mineral wagons are much more liable to this contingency. In the year 1869 the General Managers' Conference of the Railway Clearing House Association recommended the adoption of a form of coupling, draw-bar, and coupling hook, which their experience and research led them to think was the best. The directors at once adopted this, and have applied it since to their own, and insisted upon its use in the wagons of traders upon their railways.

"The company have extensively adopted the principle of interlocking their signals, points, and safety switches, and extensions are in progress wherever the circumstances appear to the directors to demand it. The advocates of this system are, however, too apt to ignore the risks involved by it, and to be unmindful of the difficulties attendant upon its introduction upon a railway already in operation. Mechanical appliances on so large a scale can only be changed by degrees, and

the machinery in question, which is complicated and costly, can only be applied gradually, consistently with the safety of the traffic of the country, which must be conducted uninterruptedly.

"The block telegraph has been largely introduced, and is being extended to those parts of the line wherever the trains are numerous, the gradients steep, the line curved, or any local peculiarities exist to make its introduction expedient.

"The directors, under circumstances of some difficulty, have not spared expense in the provision of the works embraced under the head of sufficient siding accommodation, &c., and they will continue to pursue this line of policy. It cannot, however, be concealed that the provision of siding accommodation on the scale now demanded is becoming a question of the gravest moment to the railway shareholder. Taking the case of any well-organized railway, the sidings already constructed will probably extend to nearly one-half the length of the main line.

"The directors have made many experiments with continuous brakes with varying success. On some of their express trains the brake which was tried had ultimately to be abandoned. For the local trains continuous brakes are still extensively in use with more success. Generally speaking, the experience of continuous brakes on the fast trains of this company is that they lead to the rapid deterioration of rolling stock; and while perhaps tending, as their advocates allege they do, to greater security against one class of accident—*viz.* collisions, increase in a large degree the danger of others, such as trains leaving the rails from loosened springs, axle-boxes, and other derangements of the running gear of the carriages.

"As regards the unpunctuality of trains, adverted to in your letter, no one can regret it more than the directors, not only for the inconvenience to the public, but for the loss and expense to the company. Besides the delays occasioned by the inclemency of the weather, extra carriages, horse-boxes, &c., put on and off at stations, meeting trains at junctions is a fruitful cause of delay. There are however, three causes of delay which, if the companies would act together, could be removed, and greatly improve the service; but singly no company would care to incur the public odium of applying the remedy, which would be—

"Firstly. To run the trains a little more slowly, and give a greater margin of time at junctions between the appointed hour of departure of one train and the arrival of another. Secondly. At large stations, to cease booking passengers five or ten minutes before the train is advertised to start. Thirdly. To charge for all luggage over the regulation weight, of which, particularly in summer, great quantities are carried free. This would cause much of it to be sent by goods train, and so relieve the passenger trains.

"The North British line is 836 miles long, the number of accidents officially recorded was two, showing it to have been among the most safely worked of the large railways in the kingdom. Both accidents may be placed in the category of accidents beyond the control of the management of the company. The North British system is an extensive one, forming essential links in two of the main lines of communication between England and Scotland. It has a large mineral, merchandise, and passenger traffic. The junctions, which necessarily add to the complication of railway working, are numerous; and among the many express trains which use the lines of the company may be counted some of the quickest in the kingdom. The directors have at all times been most anxious to secure the safety of the travelling public, and are not sensible of having neglected any reasonable precaution within their reach to accomplish this object.

"The financial condition of the company has not for many years past been prosperous. During the past seven years the average dividend upon the ordinary stock of the company has been 5*s.* 8½*d.* per cent. per annum, and for some years

many of the Preference Stockholders even were without a dividend. Notwithstanding this, a sum of not less than 445,000*l.* has, during that period, been expended in the construction of sidings, signals, extensions of stations, block telegraph, and other works designed to promote the convenience of the public, and to facilitate the safe and expeditious working of the traffic. The block telegraph, though costly to lay down, work, and maintain, is either in operation or in course of construction over the North British Railway for 253 miles of its length. It was introduced and extensively used some years before its merits as a system were fully recognized on many other large railways, and will continue to be extended as rapidly as possible wherever the exigencies of the case appear to require it."

The Chairman of the London and Brighton Company addressed the following letter in reply:—

"LONDON, BRIGHTON, AND SOUTH COAST RAILWAY,
"SIR, "LONDON BRIDGE TERMINUS, *Nov.* 27.

"I have the honour to acknowledge the receipt of your letter of the 18th inst., relative to accidents upon railways, with a Report enclosed from Captain Tyler on the accidents for the year 1872, which have been submitted to my Board and carefully considered.

"In the few observations which I think it my duty to submit in reply, I wish it to be distinctly understood that I and the Board which I represent are actuated by no feelings of hostility towards the Board of Trade or Government inspectors. On the contrary, we cheerfully recognize the importance of the subject; the right of public interference whenever it is clearly shown to be necessary for public interests; the fair and considerate spirit in which this interference has generally been exercised by the Board of Trade; and the value of any of the suggestions which have from time to time been made by its inspectors.

"If further and more stringent interference could in practice ensure safety, we should be delighted to see it, for as railway directors we have the deepest possible interest in preventing accidents.

"Accidents, even when they occur from unavoidable causes, always bring a certain amount of obloquy on directors and managers, and they are often attended by such enormous expense as to entail as their consequences diminished dividends and dissatisfied shareholders.

"A striking illustration of this occurred four years ago on this railway, when an accident at New Cross, caused by an experienced engine driver running past two danger-signals (one of which had been erected as an extra and special protection to the ticket platform on the recommendation of a Government inspector), cost the company more than 70,000*l.*, and practically threw back by a whole year the period of its recovery from a state of extreme depression.

"If, by any more authoritative control of a Government Department over the arrangements of that station, the company could have been relieved from the responsibility of such an accident, I need not say that the directors would have been in a much more comfortable position.

"It is therefore from no dislike to Government interference in the abstract that I proceed to point out some of the practical difficulties in the way of it, and to show that the company which I represent has not been inattentive to the due requirements either of public safety or convenience.

"You state with reference to accidents, that 'in these observations I do not attempt to distinguish between the various companies, to all of which they do not in an equal degree apply.'

"It may be sufficient as regards this railway company to state that Captain

Tyler's Report shows that upon this line, which consists of 376 miles of railway, comprising 164 stations, and on which in 1872, 5,183,568 train miles were run, and 22,783,654 passengers were carried exclusive of season-ticket holders, only three accidents occurred during that year, by none of which were any passengers or servants of the company killed, and all of which are stated by Captain Tyler to have occurred from causes entirely beyond the control of any management—*viz.* the momentary mistake or inadvertence of servants of the company—in two cases signalmen, in the other an engine driver. (See Captain Tyler's Report, pp. 15 and 20.)

"The fact of a result like this upon one of the principal railways in the kingdom, which carries such a large number of passengers under circumstances of great complication, arising from the frequency of stations and junctions, the great number and varying speed of trains, the large amount of excursion traffic, and otherwise, may, I think, be reasonably quoted rather in illustration of your remark that 'the efforts which have been made by railway companies have been attended in many respects with remarkable success,' than of the admonition that 'the present insecurity of railway travelling imposes upon railway companies the grave responsibility of finding appropriate remedies for so great an evil.'

"As Captain Tyler truly remarks, 'whatever be the amount of care taken, the item of human fallibility will always remain, and will always be the cause of a certain number of accidents.'

"On behalf of this company I may fairly challenge the verdict either of any public department, or of any competent and well-informed public opinion, to say whether the number and nature of the accidents which have occurred since the present Board and officers were responsible for the public safety are such as to exceed this limit and to merit reprobation. This much I may say with confidence, that having sat now at Railway Boards for upwards of twenty-five years, I never knew an instance where, if 'money' and 'safety' came into clear and direct competition, directors hesitated to prefer 'safety,' and to vote whatever expenditure was necessary to secure it.

"In proof that this is not mere assertion, I may refer to some of the measures which have been adopted during the last four years upon this railway to promote safety.

"A resolution was passed by the Board in June, 1869, ordering the block system to be carried out in the most approved manner over the whole line with as little delay as possible.

"Instructions have also been given to carry out the system of interlocking points and signals over the whole line.

"The rolling stock, of engines, carriages, and wagons, has been improved, and to great extent remodelled, at a heavy expense, so as to meet the exigencies of the traffic, and to adopt all the latest improvements.

"A large sum has been expended in the improvement of stations, signals, platforms, and in additional sidings, and other measures required for the safety and accommodation of the traffic.

"These measures have been carried out at a very heavy expense, defrayed in great part out of revenue, although the position of the company was one of great financial pressure.

"During the four years 1867, 1868, 1869, and 1870, the average dividend paid on the ordinary share capital of 6,839,942*l.* was only 9*s.* 4½*d.* per 100*l.* per annum.

"The total amount paid in dividends during this period of four years was 128,246*l.*, while during the same period the amount levied for taxation (over and above the income-tax paid by the shareholders in common with other taxpayers) was 331,114*l.*

"If any company could have pleaded commercial considerations as an excuse for postponing expensive improvements to guard against remote contingencies, surely it was that which I have the honour to represent; and yet, as shown above, such considerations were never allowed by the Board to weigh against the duty of providing for the greatest attainable amount of safety.

"As President of the department of the Government charged with the supervision of railways, I think I may fairly appeal to you to say whether, under such circumstances, it is right that such an excessive load of exceptional taxation should continue to be levied on the shareholders, from which the other modes of conveyance with which we are in active competition, such as steamboats, tramways, and omnibuses, are entirely, or to a great extent, exempted.

"I will now advert more specifically to the nine heads under which Captain Tyler sums up the precautionary measures which he wishes to see enforced, and from the introduction of which he anticipates 'that accidents may be in a great degree avoided.'

"1. Maintenance in high condition of the permanent way.

"No pains or expense have ever been spared to obtain this end, and the whole of the permanent way is in excellent order.

"2. Good design, construction, and material of axles.

"3. The application of tyre-fastenings, which will prevent the tyres from flying off the wheels in the event of fracture.

"The same remark will apply as to the permanent way. The best materials are always purchased regardless of expense.

"4. Improved couplings of vehicles in trains.

"This has engaged the earnest attention of our locomotive superintendent, Mr. Stroudley. The old couplings have been greatly improved, and a new system of coupling is being tried with every promise of excellent results.

"5. Signals and point arrangements, with modern improvements, including concentration and interlocking of the signal and point levers, and locking-bars for facing points.

"6. Safety points to goods or siding connections with passenger lines.

"These, as already stated, have been introduced at most of the important stations and junctions, and are being carried out universally as fast as it is possible to obtain the apparatus and remodel the arrangements.

"Expense in this, as in the case of the block system, has never been an obstacle, and had it been possible by the stroke of the pen to introduce the system everywhere at once the directors would gladly have done so. But it takes a long time to carry out complicated changes at a great variety of points and while an active traffic is in progress which cannot be interfered with.

"7. Increased use of the telegraph, with block telegraph systems for securing intervals of space in place of illusory intervals of time only between trains.

"The last remark applies with especial force to the introduction of the block system.

"It is now, as above stated, more than four years since the directors instructed the general manager to carry it out over the whole system as quickly as possible.

"It is now in operation over the whole of the main lines, and in the course of a few months will be completed over the whole of the branches.

"A moment's consideration of the difficulty of getting the apparatus and training the clerks, porters, or signalmen to its use at upwards of 250 stations and junctions will show how impossible it was to have proceeded quicker.

"It is evident that unless all the *employés* who may have occasion to use the telegraph for block purposes thoroughly understand it, the block system, instead of a safeguard, might become a cause of most imminent danger.

"8. Sufficient siding accommodation for collection, distribution, and working of goods traffic, so that goods trains may be shunted and marshalled independently, and kept out of the way of passenger trains, and may not encumber and endanger the traffic on the main lines.

"It is believed that all has been done that is required. New sidings are being continually made, as experience points out that they are desirable.

"9. Continuous brakes to be worked by the engine drivers as well as the guards, as occasion may require.

"This is the only one of Captain Tyler's nine recommendations which has not yet been adopted, and I will shortly state why:

"I do not doubt that a continuous brake would, in many cases, be an improvement, and I fully expect to see it introduced. But it is at present by no means decided which is the best system.

"Experiments are in progress, and until something is decided it would hardly be desirable to go to a very heavy expense in altering the whole rolling stock to introduce a system which might in a year or two be superseded by something better. Moreover, it is by no means proved that in many cases a continuous brake might not cause greater evils than it remedied. Carriages and wagons have constantly to be put on or taken off trains at various points, and at short notice. Unless therefore the continuous brake admits of this being done without delay, or without diminishing the efficiency of a complicated apparatus, a formidable element of unpunctuality and risk would be introduced, which, even as regards safety, might outweigh any advantage from its introduction.

"I think you will admit that these are fair reasons for caution, in waiting for the results of experiments now in progress, and that the directors cannot be charged with undue obstructiveness if they do not adopt Captain Tyler's recommendation immediately in this case, as they have in all the other measures which he points out as desirable for adoption.

"Having now, I trust, vindicated this company from any charge of wilful disregard of safety, it remains to deal with the other subject referred to in your letter —*viz.* that of unpunctuality.

"This is in some respects a more difficult subject, for while 'safety' is justly paramount and independent of commercial considerations, 'punctuality' is to a great extent a question of complicated and often conflicting considerations of public convenience.

"There is one easy and obvious mode of securing greater punctuality—*viz.* that adopted on the Continent of running trains at much lower speeds, stopping at fewer stations, giving fewer through connections with foreign and branch lines; and compelling passengers to be at stations a longer time before trains start.

"My own experience has been great, both of British and Continental railway travelling, for the last thirty years, and I say without hesitation that any attempt to cure occasional unpunctuality by introducing the Continental system, or any approach to it, in this company would be so unpopular that it could not be maintained for a fortnight. How would the British public like to be obliged to come to the station ten minutes before the train started; to have to go to a separate bureau and wait in a long file to have their luggage booked; then to be penned with all their travelling rugs and bags in a crowded room with everyone jostling for a front place? At last the doors are opened, and a rush takes place in which the strong secure the best seats and the weak and women get separated and shift for themselves.

"These are scenes of hourly occurrence at Continental stations at the starting of trains, and when the train starts the carriages are often inconveniently crowded, *and the speed is much* less than on English railways.

"Where this company runs, say, four express trains each way daily at a speed of forty-five miles an hour, including stoppages, and six stopping trains at twenty-five miles an hour, to accommodate the intermediate population at stations three or four miles apart, a French or German company, under like circumstances, would run at the most two express trains at thirty or thirty-five miles an hour, and three stopping trains at eighteen or twenty miles an hour, its intermediate stations being at least six or eight miles apart, and its branch and other connections, if any, not fitting in above once or twice a day.

"Again, British railways have generally spent millions in carrying their termini as far into the heart of large cities as possible, just to save the very five or ten minutes which, by the adoption of the Continental system, under the plea of enforcing punctuality, would be lost to the travelling public.

"Looking practically at the causes of unpunctuality as they exist on this railway, I find the following to be the most important:—

"1. Delays in starting.—Unless we adopt the Continental system it will happen occasionally that an extra number of passengers and luggage arrive at the last moment. If they get within the door of the station before the clock strikes, we consider ourselves bound to book and forward them. We could not refuse to do so (especially in the case of a line like ours, used by multitudes of City men who go up daily for business) without causing grievous inconvenience. But the inevitable result is that occasionally the luggage is not all labelled and loaded, the passengers are not all seated, or extra carriages have to be put on at the last moment. The consequence is, the train is late in starting.

"2. Delays at Road Stations.—The same thing applies at all the stations where trains stop. The delay at a small country station may not in ordinary cases be above two minutes, but on some special occasions there are extra passengers and luggage, or horse-boxes to be detached or put on, and the delay is inevitably extended to five minutes or upwards, and these delays may very possibly, on some unlucky day, accumulate over five or six different stations.

"3. Delays at Junctions.—These are the most frequent and most serious. To give a practical illustration: At some of our junction stations not less than three or four trains meet from different lines or branches. Passengers from these different trains must be able to interchange, for the streams of traffic are insufficient to pay working expenses for separate trains for each without combination. The consequence is inevitable. Every delay to any one train affects all the others, and even if all the trains are in time, if the amount of traffic interchanging in any one day is much beyond the average, time will be lost.

"If the connections are with foreign systems the delays are often greater.

"4. Delays from attaching and detaching through carriages for the accommodation of the public.

"This is done to a great extent on this railway, as the demand for it is very urgent during the season for all the principal watering-places and stations.

"But it necessarily causes delay, as the passengers could be transferred more quickly and the load of the train lightened if they were compelled to change carriages at all junction stations.

"Delays from Extra Loads, Slippery Rails, Bad Weather, &c.—These are of frequent occurrence, and are inevitable if trains are timed to run up to the speed which under ordinary and average circumstances is easily attainable.

"This line is much exposed to delays from these causes, as its traffic fluctuates extremely. During the height of the Brighton season, in the Easter and Christmas, and the Epsom, Goodwood, and Brighton Race Weeks, and on other occasions, the traffic by particular trains will often be two or three times heavier than usual Engines, therefore, which are perfectly adequate for the ordinary traffic will get

overloaded, wheels will slip, strong side winds tell more on longer trains, and the result is an occasional unpunctuality which the directors and officers deplore, but cannot always remedy.

"In fact, to look the matter fairly in the face, I know of no means of enforcing practically any materially greater degree of punctuality than now prevails in the working of this railway than that of timing all the trains to run slower, withdrawing the accommodation of through carriages, and shutting the doors of all stations against the public five minutes before trains start.

"This, as I have said, is a question of the balance of public convenience.

"Personally, as a director, I should have no objection to see my responsibility sheltered by the decree of a public authority, extending the time of the express trains between London and Brighton from one hour and a quarter to one hour and a half, of the stopping trains from two hours to two hours and a half, and all other trains in proportion—and less than this would not answer the object. But as a shareholder I should deprecate it, because I believe it would so inconvenience the public that it would drive away a large amount of traffic. As a resident in Brighton I should deprecate it, because the prosperity of Brighton depends mainly on its being within fifty miles of London, while such a decree would practically increase the distance to sixty or seventy miles; and, lastly, as an individual traveller on the railway, I should deprecate it, because I would infinitely travel, as at present, in a time so short that I do not feel it to be irksome, taking my chance of now and then being a little behind time, rather than see an unnecessary quarter of an hour added daily to my journey under the plea of consulting my safety and convenience.

"I am quite sure that the immense majority of travellers would take the same view, and that if two railways were running side by side at the same hours and fares, one at forty miles an hour, the other at thirty (with all the advantages of infinitesimally greater safety and appreciably greater punctuality which the slower speed would give), nine passengers out of ten would patronise the faster train.

"Even as a question of 'safety' I cannot doubt that very many lives have been saved or prolonged by the facilities given by our express trains for men engaged in daily business in London to go down to Brighton, Eastbourne, Worthing, or Hastings, with their families, or to reside on our suburban lines, while with three, and latterly four, express trains a day, running each way, between London and Brighton, for nearly thirty years, there has been only one accident to an express train.

"In like manner, excursion trains are, no doubt, in some slight degree, less safe than ordinary trains. But anyone who is practically conversant with excursion traffic, and knows the immense amount of healthy and innocent recreation which it has given to the toiling millions of populous cities, would hesitate to prohibit it, even although statistics should show that the odds of 17,000,000 to one against being killed on any journey by railway in an ordinary train are only half that amount in an excursion train.

"Would you, Sir, as President of the Department charged with the supervision of railways, in the interest of the public, wish us to discontinue excursion traffic?

"I mention these facts, which are the results of long practical experience, not, as I have said, from any hostile feeling to the supervision of a Government authority, nor from any necessity of vindicating this company, for Captain Tyler's Report shows that in our case there is really no charge against us; but rather to point out to Her Majesty's Government the sort of question with which they will have to deal, and the difficulties with which they will be immediately confronted, if

they depart from their present position of 'supervision' and take upon themselves any portion of the responsibility of laying down and enforcing positive regulations as to the working of railway traffic. They will find that there is no department of affairs in which general principles and abstract rules are of so little use as in railway traffic, and that everything, down even to the timing of each train, is a matter to be decided on its own merits, and very often as the result of a nice balance of conflicting considerations. They will find also that, do what they will, and however satisfied the residents in the district and habitual travellers on the line may be with the management, the general opinion of the uninformed public will always be disposed to ignore the fact, stated with so much force and truth by Captain Tyler, that 'whatever be the amount of care taken, the item of human fallibility will always remain, and will always be the cause of a certain number of accidents.'

"I am, Sir, your obedient servant,

"S. LAING, Chairman.

"The Right Hon. C. P. Fortescue, M.P.,
"President of the Board of Trade."

The Assistant-Secretary of the Board of Trade has drawn up the following Report upon the answers received:—

"To the Right Hon. C. P. Fortescue, President of the Board of Trade.

"SIR,

"In compliance with your instructions, I have the honour to submit to you the following observations upon the answers to the circular letter of the 18th of November, 1873, addressed by you, as President of the Board of Trade, on behalf of Her Majesty's Government, to the chairmen of the various railway companies in Great Britain and Ireland. Such answers have been received in nineteen cases from the chairmen of the following companies:—

"On the 24th of November, 1873, Dublin and Belfast Junction; 27th of November, 1873, London, Brighton, and South Coast; 2nd of December, 1873, Highland; 3rd of December, 1873, South Devon; 9th of December, 1873, London and South-Western; 10th of December, 1873, London and North-Western; 16th of December, 1873, Caledonian; 16th of December, 1873, Great North of Scotland; 18th of December, 1873, Midland; 18th of December, 1873, North London; 19th of December, 1873, Great Western; 24th of December, 1873, Glasgow and South-Western; 26th of December, 1873, Lancashire and Yorkshire; 26th of December, 1873, North British; 27th of December, 1873, North-Eastern; 31st of December, 1873, Bristol and Exeter; 31st of December, 1873, Great Eastern; 17th of January, 1874, Furness; 28th of January, 1874, Isle of Wight.

"In most of these replies the importance of the subject treated is duly recognized, and credit is given to Her Majesty's Government, and the Board of Trade in particular, for fairness and consideration in their manner of bringing the matter to the attention of the companies, while the value of the suggestions from time to time made by the officers of the Board of Trade is also admitted.

"The directors of the Great Western Company, however, express their regret that it should have been deemed necessary by Her Majesty's Government to address to them a letter which contains (to use their own language) 'charges as to the conduct and management of the company's affairs of so grave and serious a character;' while Mr. Moon, the chairman of the London and North-Western Railway Company, regrets not only that the President should, by implication, have made the gravest possible charge against those who manage the railway companies

of this country—that of neglecting the means which might be at their command for securing the safety of the public, but also records his opinion that such an imputation is unjust towards the gentlemen who co-operate with him in the management of the great enterprise of which he is chairman.

"The charge (if any) contained in the letter of Her Majesty's Government is, that railway companies have not to the extent of their respective powers taken care that their works and their staff are kept up to the requirements of their traffic, and that expedients of proved value for preventing danger are not adopted by them as readily as might be, and the result is stated, in the opinion of Her Majesty's Government, to have been that 'safety for life and limb has not been sufficiently secured.'

"In support of their view of the question thus at issue between the Government and themselves most of the chairmen of the railway companies point, first of all, to the proportion between the number of passengers carried and the number of passengers who have suffered death or personal injury upon their respective lines in the course of the year 1872.

"It is, no doubt, a matter for congratulation that a large number of people were conveyed in safety upon the various lines of railway in this country; this, however, was not a matter which was disputed by Her Majesty's Government, and a statement of the fact is scarcely an answer to the question, whether safety for life and limb on the railways has been sufficiently secured. Nor do I think that the statement of the proportion between the numbers carried and the numbers killed and wounded, in the way it is given at present, can be considered as an exact measure of security, or be valuable, except for the purposes of comparison between one year and another, unless several other considerations are taken into account; for, first of all, it will be observed that, in dealing with the number of passengers, holders of season-tickets are not taken into account; and this is a point in favour of the railway companies, inasmuch as each individual season-ticket holder must represent a great number of journeys. Secondly, a passenger is reckoned as a unit in forming the total, whether he goes from London to Greenwich, or from London to Bristol, and unless the journeys could be classified, and a proportion arrived at between the number of miles travelled per passenger, and the number of passengers killed and injured, no true relation between travelling and accident can be arrived at. This, no doubt, might be done by the railway companies themselves, but there is no information in the possession of the Government which would enable them to do it.

"Another point for observation is, that accidents to passengers are distinguished in the returns made to the Board of Trade by the railway companies into cases of persons killed or injured 'from causes beyond their own control,' and cases of persons killed or injured 'from their own misconduct or want of caution.' Now, the returns are made by the companies themselves, and they accordingly exercise their discretion in classifying the accidents under one or other of these categories, and it would appear that in adjusting the relative duties of the passenger and the railway companies towards one another, more is sometimes expected from the passenger than the public would be inclined to concede. Thus, the chairman of the Midland Company, in dealing with the fatal accidents that happened on his line of railway during the year 1872, after remarking that there were only two fatal accidents to passengers, says that one of these accidents was caused by a passenger jumping from a train, but he omits to state that at the time an accident had happened to the train out of which the passenger jumped, owing to some carriages having been thrown off the rails, when travelling at a speed of fifty miles an hour, through the breakage of a tyre; and Mr. Moon, the chairman of the *London* and North-Western Railway Company, after dealing with the number of

deaths of passengers from causes beyond their own control in the year 1872, says that for the year 1873 there had been up to the 10th of December only one fatal accident of this class on his line, and this accident, he seems to consider, should rather be ranked among those caused by the sufferers' own want of caution, though it appears to have been brought about by the passengers of a train having been made to alight in the dark on the ballast at a distance from the platform of a station, when one of them, a woman with a child in her arms, was knocked down by a passing train as she was making her way to a place of safety. Mr. Moon adds, 'Of course in my remarks I do not include the melancholy accident at Wigan, which, after the most searching investigation, official and otherwise, has not been proved to result from any defective arrangements of the company.'

"Whatever boundaries may be fixed by the railway companies as the limit of their control over the causes which lead to accident, and in spite of the fact that a large number of passenger journeys are effected in safety, the public will hardly disagree with Her Majesty's Government in the view that 'safety for life and limb has not been sufficiently secured,' when they reflect that in the last six months 120 passengers have been killed and 984 injured, of whom no fewer than 48 were killed and 854 injured from causes which are admitted to have been 'beyond their own control.'

"It is gratifying to the Board of Trade to observe, that in their replies the chairmen of the railway companies agree, without exception, that the measures of safety recommended by the Department are sound; and that by narrating in each case the extent to which they have complied with these recommendations, they give an evident proof that this agreement is not merely theoretical.

"An even stronger proof, perhaps, of the soundness of the measures adovcated by the Department is the statement of the chairman of the Lancashire and Yorkshire Railway Company, that in the thirty-one cases of accident which had occurred on that company's line, the directors so far agreed with Captain Tyler's view that sixteen of the number might have been avoided if the improvements suggested by him had been adopted, as to give orders to place the suggested improvements in operation. At the same time, some of the statements of the chairmen appear to be somewhat imperfect, since, in recapitulating the works which have been performed, and the money which has been expended, they are not sufficiently careful to compare the simultaneous growth of traffic with the additional works provided, or to distinguish between those new works which are required for the purposes of commerce and profit, and those which are due to the requirements of public safety.

"Thus, the chairman of the North-Eastern Railway Company points to the fact that during the last three years new sidings to the extent of 147 miles have been laid down upon his system, and that nearly two millions of money have, at the same time, been expended or are about to be expended in the extension of works in connection with lines previously opened for public use and for the purposes of providing additional rolling stock, but during the years 1869–1872, the gross receipts of the North-Eastern Company have increased 30 per cent., their net receipts 24 per cent., and the number of passengers carried by them 50 per cent., while their paid-up capital has in the meanwhile increased only 11 per cent., so that it still remains to be shown whether the expenditure for which they claim credit has even kept pace with the growth of their traffic.

"On the other hand, it may be remarked that the North-Eastern Railway Company had, at the end of 1872, 1337 miles of line open, and that of this length 1163 miles were worked for passenger traffic. Out of this length only 131½ miles of double, and 12¼ miles of single, line were worked on the absolute block system

and 8½ miles of double, and 18½ miles of single, line on the permissive block system; while out of 2399 instances in which the Board of Trade would require points and signals to be interlocked, the company had only done 886; and in 1693 cases where safety points are required for goods lines and sidings, they had only completed 984.

"The chairman of the Great Western Railway Company, again, states that in the year 1872 his company substituted the narrow for the broad gauge throughout the whole distance from Swindon to Milford Haven, representing about 500 miles of single line, and that they contemplate a similar operation in the ensuing year in other important and extensive parts of their line. This change, no doubt, was most important, and, for commercial reasons, most expedient; but it can hardly have been deemed to have been made for the purpose of increasing the safety of travelling by railway, as the Great Western Company would itself admit that when accidents occur on the broad gauge system by trains getting off the rails, the results are likely to be far less serious to the passengers than on the narrow gauge railways; and the change, therefore, however beneficial from a commercial point of view, cannot, so far as mere safety to life and limb is concerned, be regarded as an unmixed boon to the public. And in the case of this company also, it appears that out of a total of 2460 cases where the interlocking of points and signals is required, the company had in 1873 only completed 1022, leaving 1438 to be done; while out of 1774 cases where safety points in the cases of goods lines and sidings are required, the company had only provided 580. Nor, with respect to the block telegraph, does it appear certain that the company have done all that can be expected of them, when out of a total of 1402 miles worked for passenger traffic, they have adopted the absolute block system on 226 miles 49 chains of double line, and 224 miles 67 chains of single line, and the permissive system on 33·65 miles, a proportion which only just exceeds one-third of the whole length; while their neighbours, the Bristol and Exeter Company, work the whole of their system, with the exception of two miles, on the absolute block system. Nor, although the Great Western Company have made great expenditure upon the matters to which they refer, have they as yet been able to get rid of sundry very objectionable one-sided stations upon their line, which have often been reported against.

"Some companies have been for some years active in putting into operation the means of safety enumerated by Captain Tyler, and with respect to them it will be found as a rule that they suffer least from accident and pay least for compensation. But with respect to others it must be said that their energy is of recent date, and the statement of their activity cannot be accepted without qualification. Thus, the chairman of the London and North-Western Railway Company states that his company was the first to introduce on a large scale, in the year 1864, the system of interlocking points and signals, patented by Mr. Saxby. The invention, however, of the interlocking of points and signals, to prevent signalmen from inadvertently or carelessly making mistakes, was brought out in 1856, and was not till long afterwards made use of on the London, Brighton, and South Coast Railway, where the inventor, Mr. Saxby, was then employed. I am informed by Colonel Yolland that the principle of interlocking was accepted as most desirable by some of the officers of the London and North-Western Company who met him and the officers of the North London Railway Company at the Hampstead and City Junction in 1859, and it was adopted at the entrance to the Victoria Station on the London, Brighton, and South Coast Railway, which was then, and is still, regarded as a complicated and dangerous station to work, in the year 1860. In the year 1860 also it was generally enforced by the inspecting officers of the Board *of Trade on* new railways.

"A collision occurred on the 1st of January, 1862, at the Walton Junction of the London and North-Western Railway, near Warrington, by which two men were injured, one of whom subsequently died; and Captain Tyler, in his Report on the accident, recommended that the levers of the points and signals should be properly interlocked. This Report was communicated to the London and North-Western Company, and its receipt was duly acknowledged. On the 29th of June, 1867, a very lamentable collision occurred at the same spot, by which eight passengers were either killed on the spot, or subsequently died of the injuries received, and about seventy persons stated themselves to have been injured. Colonel Yolland, in his Report on the accident, dated the 30th of July, 1867, pointed out that if Captain Tyler's recommendation, which had been made five years before with relation to this very important junction, had been attended to, this terrible accident, which was due entirely to the mistake of a signalman, could not have happened.

"It has not been disputed by the Government that much has recently been done by the railway companies; the question has been, and still is, whether enough has been done; whether the companies have been sufficiently penetrated with a conviction of the necessity of supplying all reasonable means of averting accidents, or whether they have not too often waited until the conviction has been forced upon them by the experience of disaster on their own lines.

"Thus, in addition to the case of the accident at Walton Junction on the London and North-Western Railway already mentioned, it would seem, from the experience of this Department, as if the energy of the directors of the North-Eastern Railway Company, in introducing modern improvements, had been roused in a remarkable degree by the occurrence of serious collisions at Thirsk in May, 1869, and Brockley Whins in December, 1870, when five persons were killed and fifty-nine injured; and similarly in the case of the Caledonian Railway Company, that little was done in this respect until after the occurrence of the fatal accident at Kirtlebridge, in October, 1872, when ten passengers were killed and fifteen injured. The chairman of the Brighton Company dates the commencement of the energetic movement upon his line from a resolution passed by the Board in June, 1869, ordering the block system to be carried out in the most approved manner over the whole line with as little delay as possible, and he cites, as an instance of financial disaster caused by railway accidents, the case of collision which cost the company more than 70,000*l*. It is not known whether the accident had any direct connection with the Board order, but the collision occurred in the same month (June, 1869) in which the order was passed; and certainly in other cases it is impossible not to remark that improvements often follow accidents which might well have preceded them. It is the opinion of the officers of the Department that of late years the companies have shown increased energy in introducing improvements, but it is also to be remarked that these improvements have been coincident with increased attention on the part of the public and Parliament to the subject of safety in travelling, as evinced, for example, by the inquiry held last Session by the Committee of the House of Lords upon Lord Buckhurst's Bill. It has been the object of this Department, by its Reports, to inform the mind of the public in this respect, and, so far as lay in their power, to show to what specific points attention should be directed. If the public be well informed, and their demands reasonable, the stimulus to improvement which they will by this means supply must be acknowledged to be healthy by the railway companies themselves.

"On the subject of unpunctuality the replies of the chairmen of most of the companies seem to amount to this:—That they cannot help it; for that they could only obviate it by placing the travelling public under conditions which they would not submit to. Only one, the chairman of the Great Western Railway Company, challenges the allegation that unpunctuality, to any great extent, exists. He

supports his statement by statistics, showing, among other things, that out of a total of 255,986 passenger trains run on his line in 1873, 73·21 per cent. arrived at their destination punctually, or within five minutes of the time fixed by the time-tables. He does not, however, classify the trains, or show how many were trains running short distances and how many long ones; and this is a matter of some importance, as it is evident that it makes all the difference whether the train which is five minutes late is a local or suburban train running a short distance, or a train which has to travel from Milford to London. This is a matter upon which the Board of Trade cannot produce absolute proof, inasmuch as the running times of the various trains are not in the possession of the Department; on the other hand, it is a matter upon which the public at large are competent to form an opinion, and the fact remains that, among the public, there is a conviction that unpunctuality prevails to an extent greater than can be accounted for by the theory stated by Mr. Moon, that the time fixed 'being such as can be maintained under ordinary circumstances,' 'there is always a liability to occasional derangement by extraordinary influx of passengers,' &c. If unpunctuality is indeed irremediable, it is a matter very much to be deplored; for, whether it ought to be a cause of accident or not, there is no doubt that it is so in a high degree. When traffic is crowded, and a train behind time, it cannot be expected that servants will always keep the main line clear, and thus an endeavour will be made to perform some shunting operation, in the midst of which they will be surprised by the arrival of the train for which they should have been waiting.

"The subject would be in a more hopeful state if it should prove that the cause of the evil lies in the fact that railway companies, under the pressure of competition, endeavour to do more than they can accomplish; for in this case it may be expected that a sense of the waste and risk incurred under the present system will lead the railway managers to meet the difficulty by allowing more time for necessary work.

"Although the railway companies appear generally desirous of showing that they have been zealous in carrying out the various means of public safety recommended by the Board of Trade, yet some of them make use of an argument which seems inconsistent with their conduct in this respect. Thus the chairman of the North-Eastern Railway says that 'whatever arrangement of a mechanical nature may be adopted, it is upon the vigilance and care of those employed that reliance must chiefly be placed for the safe working of railways;' and the chairman of the Great Western Railway Company, while admitting the expediency of adopting and applying every improved means of securing safety, yet warns the Government, as one who has had daily experience in railway work, that grave and serious dangers may arise from too great reliance upon mechanical appliances as substitutes for manual labour; and, after touching upon physical circumstances which may interfere with the accurate working of machinery, emphasises on the peculiar risk as the feeling of false security which the universal adoption of mechanical appliances supposed to be perfect in their operation is apt to produce in men who work them, and he concludes his warning with the statement that if men are induced to believe that danger may be entirely prevented by mechanical inventions and expedients, their own vigilance will be apt to be lulled to sleep; while the chairman of the London and North-Western writes that 'It should be observed with regard to all these mechanical appliances, whether brakes or interlocking, or any others which are believed to meet any particular danger, that they are liable to create a feeling of confidence in the men, who are, therefore, naturally induced to risk more than they otherwise would do.'

"This argument, which is here advanced only in depreciation of the means of safety recommended by the Board of Trade, has occasionally been developed much

further by eminent gentlemen connected with railways, so that the Board of Trade has even been accused of causing accidents by means of the precautions recommended by them.

"The argument appears to be, first, that it is upon care and vigilance in the railway servants that the public must rely for safety in travelling; and, secondly, that the means of safety recommended are bad in themselves, because they diminish the exercise of this care and vigilance on the part of the railway servants. The corollary of this is, of course, that the more you rely upon the care and vigilance of your servants, and the less you rely upon mechanical contrivances, the greater will be the safety attained.

"It is not easy to see precisely to what mechanical contrivances these arguments are directed. The chairman of the Great Western mentions three, *viz.* the interlocking system, the block-telegraph system, and the system of continuous brakes, including the block-telegraph system specifically under the term 'mechanical contrivances.' The chairman of the London and North-Western speaks of 'all those mechanical appliances, whether brakes, or interlocking, or any others,' while the chairman of the North-Eastern speaks only of 'arrangements of a mechanical nature.' Now the block-telegraph system, though it may have its peculiar weak points, is not a mechanical contrivance at all, but a system of working. The other means of safety recommended by Captain Tyler, in his Report upon the Railway Accidents of the year 1872, to which the term 'mechanical contrivance' might be applied, are improved tyre-fastenings, improved couplings, improved signal and point arrangements, and continuous brakes. With regard to these, it is not easy to see how the use of defective tyre-fastenings or inferior couplings could, by stimulating the care and vigilance of railway servants, contribute to the safety of the travelling public. It must therefore be that the arguments levelled against the employment of mechanical contrivances can apply only to the introduction of signal and point arrangements with modern improvements included generally under the term 'locking apparatus,' and the use of continuous brakes. Now, what is the locking apparatus? It is a mechanical arrangement by which a signal cannot be given for a train to pass in any particular direction until the points are set right for that train; and so long as a signal is exhibited for a train to pass in a particular direction the points are thereby fixed, and kept so as to be right for the train to pass in that direction. By this arrangement, so long as all the signals are at 'danger,' the points are free to be moved in any direction; but so soon as any one 'all-right' signal is given, the points become locked in the proper position relatively to that signal, and they cannot be moved until that signal has been altered; while in the absence of locking apparatus the points can be set in any position, and can be moved at any time by the pointsman independently of the position of the signals.

"It is no doubt true that if the points and signals at a junction be not interlocked, the power which the signalman has of setting the points, either right or wrong, in relation to the signals exhibited, must cause a greater strain upon his vigilance, and demand a greater exercise of care; but whether by this strain more or less safety is caused to the travelling public is a question which might be left safely to the public themselves to decide, even if the experience of fatal accidents had not drawn the conclusion already.

"With regard to the block system, the criticisms passed on that proceed not upon the ground of the liability of mechanical arrangements to fail, but upon the assumption that it produces a feeling of false security among the servants who are working under it. This assumption is very generally made, and, indeed, admitted to some extent by Captain Tyler in his Report, yet it is doubtful whether accidents traceable to it have hitherto occurred, while the accidents attributable to the

want of the system are very numerous. Engine drivers are not more anxious than are any other class of persons to be burnt, scalded, or crushed to death, and I would submit that if the use of this system is, in the language of Mr. Moon, 'liable to create a feeling of confidence in the men,' it would be difficult to discover a more forcible testimony in its favour than the feeling of security thus created. The same arguments apply to the introduction of continuous brakes. This question, no doubt, is not so far advanced as others; but it is true that several effective systems are at work in the country, that accidents attributable to the feeling of security caused by their employment have not yet been shown to occur, while accidents which might have been prevented or alleviated by their use occur frequently, and the reliance placed on the brakes by the men who use them, if it exists, must be the strongest possible argument in their favour.

"It is thoroughly well established on railways, as in conducting other affairs, that the very best men that can be procured, no matter at what cost, are all liable to, and many of them do occasionally, make mistakes, which, when made on railways, lead sometimes to very lamentable accidents. I need only instance the case of the collision which occurred at Kirtlebridge on the 2nd of October, 1872, when ten passengers and the engine driver were killed, and fifteen passengers injured, owing to a mistake on the part of the station-master, a zealous and hard-working man, which he could not have made if the points and signals at the place had been interlocked.

"It has lately been remarked by a great authority on railway matters that 95 per cent. of railway accidents are attributable to the indiscretion which the most careful men must occasionally commit; but probably few people would be inclined, as he seems to be, to draw from this statement the conclusion that the effect of the means of safety recommended is to destroy self-reliance, or to express a wish for the abolition of those which exist in order to return to older modes of working. Happily for the travelling public, no holder of these sentiments has hitherto had the courage of his opinions, and in practice it will be found that at the most complicated and dangerous points of railway traffic the tendency is to adopt the mechanical contrivances recommended by Captain Tyler as means of safety, as though the theory of the Board of Trade were admitted, that they economise and supplement the vigilance and care of the men and guard them against, instead of leading them into, error.

"If arguments of this sort were not continually put forward by railway companies it would seem useless to insist upon matters which have already been sufficiently dealt with by Captain Tyler. In his General Report for 1872, page 23, he says:—

"'Whatever be the amount of care taken, the item of human fallibility will always remain, and will always be the cause of a certain number of accidents; but the number of accidents from even this cause may be very much reduced by improvements in regulations and discipline, by greater care in the selection, training, payment, and employment of competent men in sufficient numbers and for reasonable hours, and by providing them with the requisite siding and other accommodation, with proper signal and point apparatus, with the best means of securing intervals between trains, with sufficient brake power, and with other necessary appliances. It is a favourite argument with those who oppose the introduction of some of these improvements, or who make excuses for the want of them, that their servants are apt to become more careless in the use of them in consequence of the extra security which they are believed to afford, and it is desirable to consider seriously how much of truth there is in the assertion. There may no doubt be a tendency sometimes on the part of engine drivers who *are working* under a block system to consider that the line is certain to be clear

of trains ahead of them, and not therefore to keep so good a look-out between the signal cabins; or with those who are working with an ample supply of brake power to run with greater confidence, and to leave less margin for pulling up their trains, under the knowledge that they can, when necessary, bring their trains to a stand within a comparatively short distance. The guards and brakesmen also, under similar circumstances, do not see naturally the same necessity for running back to warn following trains in the event of an unusual stoppage, when they are working under the protection of the block system, as when they are aware that safety depends on their unaided exertions; and there may, no doubt, be a further tendency for the servants to run at higher speed, and for the officers to encourage or permit higher speed through facing points, and through places at which greater risk is incurred, in consequence of the greater security that is afforded by locking apparatus and locking bars. . . . . But, making the most of these tendencies to confide too much to additional means of safety, the risk is proved by experience to be incomparably greater without them than with them; and, in fact, the negligence or mistakes of servants is found to occur most frequently, and with the most serious results, not when the men are over-confident in their appliances or apparatus, but when, in the absence of them, they are habituated to risk in the conduct of the traffic. In the daily practice of railway working the trains must be run as nearly in accordance with the time-tables as circumstances will permit; shunting must be got through, with or without suitable accommodation, and station-masters, porters, signalmen, engine drivers, or guards are frequently placed in difficulties which they have to surmount as best they can. The more they are accustomed to incur risk in order to carry on their business, the less they think of it, and the more difficult it is to enforce discipline and obedience to regulations. The personal risk which is encountered by certain classes of railway servants has never yet been precisely ascertained; but it is, as shown by the proportionate number of casualties, very great; and it is difficult under any circumstances to prevent men who are in constant danger themselves from doing things which may be a source of danger to others, or, at all events, from strictly obeying regulations for which they do not see altogether the necessity, and which impede them in their work. This difficulty is increased with, and in proportion to, the want of necessary means and appliances, and is diminished when, with proper means and appliances, stricter discipline becomes possible, safer modes of working become habitual, and a higher margin of safety is constantly perserved. Station-masters, porters, and yardmen, working constantly under-handed, without sufficient siding accommodation, with defective signal and point arrangements, and without the proper use of the telegraph, are, so to speak, trained to be reckless, and are almost obliged to carry on their work habitually in a way that would not be contemplated, and would be inexcusable under better arrangements.'

"And again:—

"'The want of care, or mistakes of officers or servants, may to a great extent be obviated by the application of improvements:—(1) of block-telegraph working and suitable signal and point arrangements with locking apparatus; (2) of proper siding and other accommodation for working the traffic; and (3) by strict discipline, which can only be properly maintained when those other means of safety are provided. Railway work is a description of work which must be got through. When it cannot be performed without risk, the risk is incurred. The officers and servants of the companies are too frequently induced, if not compelled, in the absence of necessary means, appliances, or accommodation, to disobey printed rules or to adopt hazardous methods of working, and in the course of their daily work to become habituated to operations which they would themselves, in the first instance, see to be objectionable. They are often unduly blamed when

accidents actually occur, because their difficulties in these respects are not sufficiently known or considered.'

"Two accidents which have lately occurred will afford a just commentary upon these remarks. One happened near the Guide Bridge Station of the Manchester, Sheffield, and Lincolnshire Railway Company, on the 2nd December, 1873, when one passenger was killed and thirty-seven others were injured, owing to the driver of a Midland passenger train, which came into collision with a Cheshire Lines passenger train, having run past the signal at the Oldham-road cabin, which stood at 'danger.' Upon this case Captain Tyler, who inquired into the cause of the accident, observes:—

"'In looking to the causes of this collision, there can be no doubt that the Midland engine-driver, Clancy, neglected to obey the distant signal from the Oldham Junction, which was at "danger," and the lamp of which was burning brightly. No excuse can be made for him. He ought, even though the rails were in a greasy condition, with the proportion of brake power at his command, to have brought his train to a stand short of the Cheshire Lines train, which he did not apparently expect to find in his way on that side of the Oldham Junction. The presence of the goods inspector with him on the engine may have led him to be less attentive to his duties. It is to be expected, as stated in the above evidence, that when the improvements in connection with the Guide Bridge Station, and the lines in its neighbourhood, above referred to, have been carried out, the block system will be introduced, by the aid of which, when it is properly worked, such collisions may best be prevented on this busy and important section of railway. It may be observed, in the meantime, with reference to the observations so frequently made, that there is danger in the introduction of the block system, lest the engine drivers should, by being led to trust to it, fail to keep so good a look-out, and to exercise so much caution as they would in working without it, that in this case, as in very many others, the engine driver was not, by the absence of it, induced to exert the ordinary amount of caution which was required of him for the avoidance of the present collision.'

"The other accident occurred near the Bolton Station, on the Lancashire and Yorkshire Railway, between a down passenger train from Manchester, which came into collision with an empty wagon train, the wreck of which was immediately afterwards run into by an up passenger train for Manchester. In this double collision forty-two passengers and six servants of the company were injured. After narrating the circumstances of the case, Captain Tyler, who was the officer appointed to investigate the case, concludes as follows:—

"'The above evidence contains, probably, some of the most striking revelations concerning the working of railway traffic under difficulties that have yet been brought to light. It must be read in full to be appreciated. It is vain to attempt, in condensing it, to give an adequate idea of it. The signal cabins are said to be twenty years old, and their condition lends confirmation to the statement. The appliances connected with them, or in them, are in keeping with them. The inspectors and the signalmen tell the same extraordinary tale. The sum of it is that the accommodation at the Bolton Station on one side of the tunnel, and at the Bullfield sidings on the other side of it, is quite insufficient for the traffic to be dealt with. Some of the trains are timed to leave Bolton within two or three minutes of one another, and yet signalmen are discharged from the company's service for not obeying a rule which directs that they shall be kept five minutes apart. The company's printed regulations in this respect have been practically in abeyance, while nominally in force, at all events for eight years, during the whole of which time alterations in the mode of working or increase *in the accommodation* must evidently have been required. Goods trains are sent